



# The Blast Furnace and Steel Plant

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# The Blast Furnace *and* Steel Plant

VOL. VII.

PITTSBURGH, PA., OCTOBER, 1919.

No. 10

## Steel Treaters Hold First Convention

**Strong Technical Program and Exhibition of Unusual Interest  
Mark First Annual Convention and Exhibition of American  
Steel Treaters' Society—T. E. Barker Re-elected President.**

The first annual meeting of the American Steel Treaters' Society was held in the Seventh Regiment Armory, Chicago, September 23-27. The convention marked a great achievement for this society. It is doubtful whether a national society of this character has ever held such a successful meeting in the first year of its growth. The main purpose of the society is "to promote the arts and sciences connected with the heat treatment of steel." The scope of the society is tremendous in that it covers the heat treatment of steel not only in a certain specific industry but in all

The society elected the following officers for the next year: T. E. Barker, president; E. J. Janetsky, first vice president, D. K. Bullens, second vice president; A. G. Henry, secretary; A. F. Boissoneau, treasurer; board of directors, J. Fletcher Harper, Julian Pollak, H. G. Weidenthal and A. F. McFarland; W. H. Eisenman, business manager.

T. E. Barker in his address of welcome to the First Annual Convention, reviewed the founding of the society, and the various steps in its progress. Mr. Barker said in part: "In the early part of September,



Technical session of American Steel Treaters' Society.

industries. Already this organization is holding regular monthly meetings in Chicago, Cleveland, Pittsburgh, Milwaukee, Philadelphia, Cincinnati, Buffalo, Rochester and New York. A monthly journal of this society contains a large amount of interesting and practical data dealing with the various phases of heat treating.

In addition to an exceedingly comprehensive and well presented technical program read at this convention, a very interesting exhibit of equipment manufacturers appeared in the main hall of the armory.

1918, the few interested men took upon themselves to mail a letter to a number of men in and about Chicago suggesting the formation of a society for the study and development of the art of heat treating steel and asking them to attend a dinner meeting at the City Club on September 18, for the discussion of the project. This letter brought an enthusiastic result, an organization resulted and officers were elected. From the birth of our society, one success has been stepping on the heels of a preceding one and today we are opening a convention and exhibit worthy of



an organization of many years standing." Upon his reelection to the presidency of this organization, Mr. Barker pointed out some of the things the society expects to accomplish in the future, saying:

"I can see as a result of this convention and exhibition an awakening of many to a realization of the value and possibilities of this society which will increase its prestige and membership.

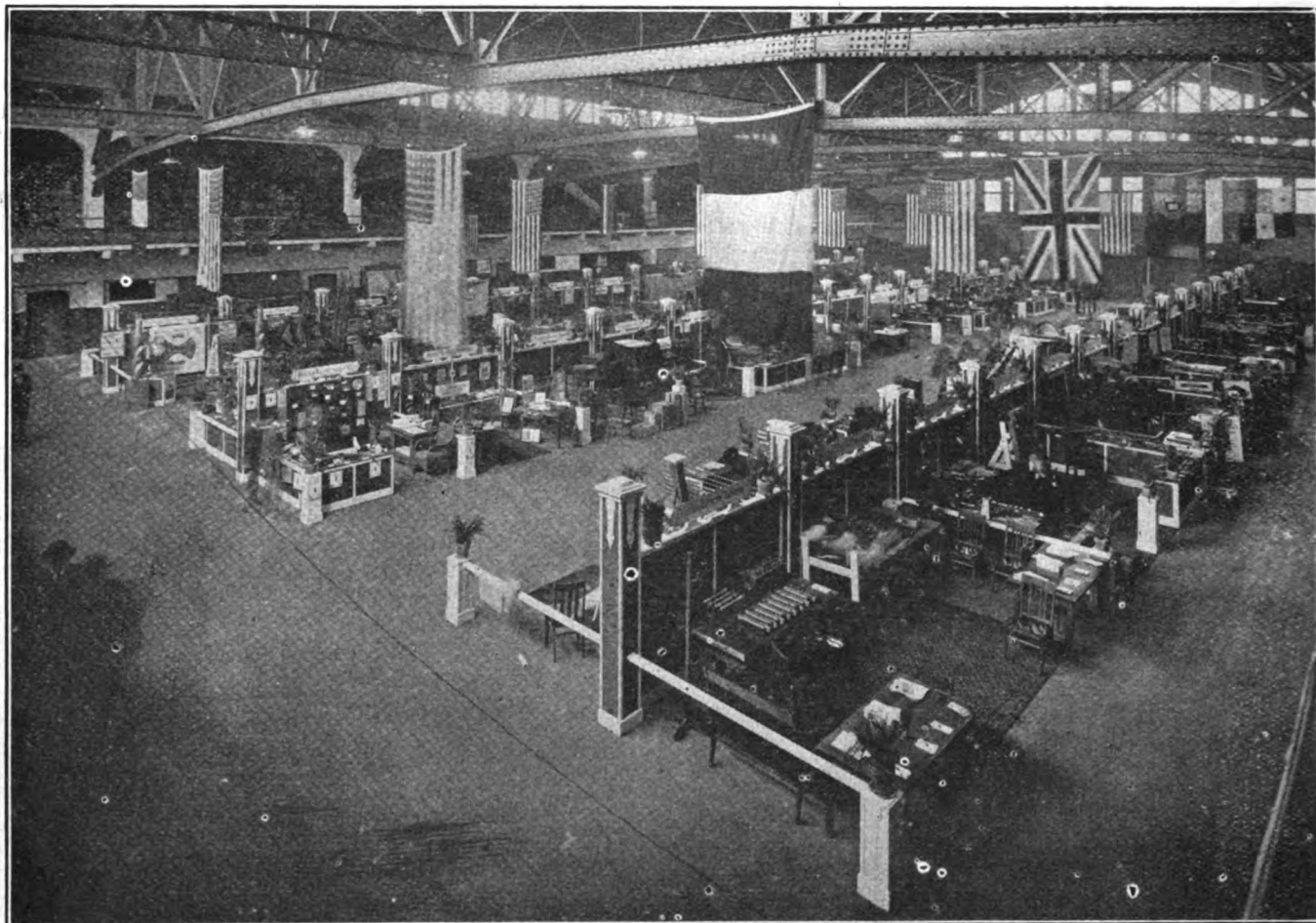
"I can see our Journal acquiring strength, force, and momentum with every issue. I can see in the not distant future the best equipped chemical and physical laboratory in the world, shorn of all commercial influences, manned by the best talent, devoted exclu-

construction, metallurgical and electrical engineers.

"Of course it is not to be expected that everything of value, as a guide to heat treaters or designers of heat treated parts, will originate in this laboratory but it will render an exceedingly valuable service in checking, proving or demonstrating the various statements, theories and processes submitted by the craft at large and by elaborating upon the research work conducted by private or commercial laboratories."

Speaking of future conventions, Mr. Barker seemed very enthusiastic and said:

"Another vision, which appears in my dream mirror, is of our 1920 convention and exhibition. Al-



Exhibition at Seventh Regiment Armory, Chicago, American Steel Treaters' Convention.

sively to research and the standardization of heat treating processes. And, eventually this will be housed in our own well appointed building which will also provide suitable offices for our national headquarters.

"From this laboratory there will issue, as standards are proven, data sheets of inestimable value to our members and to the business interests with which our members are associated. And, later, the compilation of the records of this laboratory work, combined with that which is best from other sources, will be to the metallurgist, the heat treating department and the designer of heat treated parts, what the "hand books" such as "Kents" are today to the mechanical,

ready the beckoning hands of several of the commercial associations of our largest Eastern cities are apparent, ready to throw wide the portals for our reception and entertainment and, in responding to one of these calls, we shall stage a program which will far excell the present one. I can see at our 1920 convention, not one convention room but several, each devoted to one or more different functional sections; one to case hardening, one to the discussion of alloy steels and their treatments, another to the discussion of high speed steel problems, and still others covering carbon steel problems, forging, piercing and forming dies, etc., so that each one who attends may select subjects which are of the greatest interest to him."

If the growth of this society continues within the next year as it has during the first year of its existence the annual meeting of this society will undoubtedly be one of the largest technical sessions of any society held in the entire country.

Harry H. Merrick, president of the Chicago Association of Commerce, delivered a very strong and interesting address of welcome to the society. He complimented the organization upon its rapid growth. Upon its purpose and upon its first convention, Mr. Merrick referred to the present industrial unrest, as follows:

"We must stop this idea that a few men can tie up a great industry, that one man can justify himself in saying that the strike of the steel and iron workers is simply a warning that the American Federation of Labor may demonstrate that it has the power to strike. That sort of thing is absolutely wrong in this country. There may be evils in the trade, conditions among the labor men that require attention and adjustment. But all the world needs production today. Today the farmers are halting on account of this labor cry and yet men are paid more heavily than in the history of the world, men are spending money more wastefully than ever before and in reality the trouble that brings about these strikes is occasioned by the agitator."

Mr. Merrick further pointed out that in his opinion an organization such as the American Steel Treathers' Society would go far toward instigating and developing technical progress and industrial research.

The technical program prepared for this convention appears as follows:

### Technical Program

"Metallurgy—In the Manufacture of High Speed Steel," Roy C. McKenna.

"Heat Treatment of Drop Hammer Dies," C. U. Scott.

"Factors to Be Considered in the Heating and Cooling of Steel," C. B. Barnhardt.

"Effects of Forging Temperatures on the Heat Treatment of Steels," D. R. Cornell.

"Annealing of Chromium-molybdenum and Chromium Steels," John O. Liebig.

"Selection of a Carburizing Material," H. B. Knowlton.

"Controlling the Cost of Pots and Boxes," H. H. Harris.

"Metallography of Steel," Cyril J. Atkinson.

"The Cause of Failures in Case Hardening," T. G. Selleck.

"Case Hardening in General," George C. Nixon.

"Annealing Large Sections of Cast Nickel Steel," G. A. Brewster.

"Heat Treatment of Steel for Machine Parts," Robert M. Taylor.

"Heat Treatment of Cast Steel," Alvin N. Conarroe.

"Phenomena of Annealing," Herbert S. Wilson.

"Heat Treatment of Ball Bearing Steel," Carl T. Hewitt.

"Heat Treatment of Spring Steel," Fred A. Volstorff.

"Heat Treatment of Rifle and Machine Gun Barrels," Arthur W. F. Green.

"Submarine Crank Shafts," T. E. Gladden.

"Heat Treatment of Tools for Alternate Contact," John J. Jones.

"Heat Treatment of Steels for Chisels," N. B. Hoffman.

"Hump Method of Heat Treating," George W. Tall, Jr.

"Heat Treatment of Flat Spring Steel," Harry E. Hemstreet.

"Glimpses in the Production of Munitions," Lieut. Col. A. E. White.

"Recent Developments in the Testing of Steel and Steel Products," Herman A. Holz.

"Physical Endurance Tests in Case Hardened and Heat Treated Parts for Auto Trucks, Tractors, and Agricultural Implements," W. G. Lottes.

"Fuel Consumption and Its Waste, as Affected by the Proper Use of Pyrometers and Designs of Furnaces," C. S. Gordon.

"Effect of Heat Treatment and Mechanical Work on Physical Properties of Mild Steel," Wilfred Hanby.

"Results of Various Heat Treatments on Alloy Steels as Used in the Structural Parts of Air-Craft," J. L. Harkness.

"Cast Steel and Its Heat Treatment," S. C. Johnson.

"Iron and Steel for Electrical Purposes," Frank P. Fahy.

"Pyrometry in the Steel Industry," Richard P. Brown.

"Electric Heating of Steel," E. F. Collins.

"An Investigation on Hot Rolled and Forged Four-Inch Steel Bars," John H. Higgins.

"Relation of Fuel and Furnace to Heat Treaters," Robert P. Maynard.

"A New Compensated Heatmeter," Charles P. Frey.

"The Metallurgist and His Relation to Shop Practice," Harold J. Smiley.

"Salts for Quenching," Shipley N. Brayshaw.

"Thin Armor Plate," L. E. Howard.

\*Presented by title.

### Exhibition

Equipment manufacturers who presented exhibits at the convention and the products which they exhibited are as follows:

ALLEN COMPANY, LTD., EDGAR—High speed tool steel. In charge of exhibit: Edward Cornell, Henry Steen, C. W. Craig, E. Smart.

AMERICAN GAS FURNACE COMPANY—High speed steel furnace; oil furnace, lead hardening furnace, rod and forge furnace, oven furnace, heat regulator, nichrome drum. In charge of exhibit: D. H. Stevens, E. J. Casper.

AMERICAN STEEL TREATERS' SOCIETY—Chicago chapter.

ARMOUR INSTITUTE OF TECHNOLOGY.

ATLAS CRUCIBLE STEEL COMPANY—Finished tools, tool steel ingots and billets, hot rolled and cold drawn tool steel bars and shapes, drill rod, ferro-alloys, motion pictures (mfg. of tool steel). In charge of exhibit: Frank Lounsherry, William B. Moulton, H. Hardwicke, W. F. Abel, G. Charlton, W. G. Zetsche.

BELL & GOSSETT Co.—Case hardening materials, high temperature cement (Hytempite), shore instruments, (stereoscope, pyroscope), enamelite. In charge of exhibit: W. C. Bell, E. J. Gossett, George A. Mies, M. W. Kingsley.

BLAICH COMPANY, ALFRED O.—Carburizing materials, general exhibition of carburized steels, particularly those relating to the automotive industries. In charge of exhibit: A. O. Blaich, president; J. A. Howland, T. G. Selleck, F. Pugh, H. Goggins.

BLANCHE & Co., INC., L. C.

BROWN INSTRUMENT COMPANY—High resistance indicating instruments, high resistance recording instruments, crane

formation point recorders, automatic signaling pyrometers, automatic temperature control, recording and indicating thermometers, pressure and vacuum gauges, thermocouples and protecting tubes, Brown precision heatmeter. In charge of exhibit: R. P. Brown, president; F. C. Mahoney, S. W. Thal, G. W. Lazear, G. W. Keller.

**BRISTOL COMPANY, THE**—Pyrometers and Pyrometer regulators. In charge of exhibit: F. B. Beddell, H. L. Griggs, C. C. Eagle, Jr.

**THOMAS BUCHANAN COMPANY**—"Case-Hardo." In charge of exhibit: Charles Storch, Thomas Buchanan.

**BUDA COMPANY, THE**—Storage battery industrial trucks. In charge of exhibit: J. J. Pool, Gumpfer.

**CENTURY STEEL COMPANY OF AMERICA**—Specimens of tools made from "Centurion Superior" high speed steel. In charge of exhibit: Harry L. Whitney, C. R. Trimmer, C. B. Lasiter, J. W. Gage.

**CHICAGO FLEXIBLE SHAFT COMPANY**—Oil tempering furnace, salt bath furnace, cyanide furnace, oven furnace, case hardening furnace. In charge of exhibit: Peter Blackwood, H. A. Abdill.

**COLONIAL STEEL COMPANY**—Tool steel bars, (high speed, carbon and alloy). Crucible process in four different stages of melting, drill rods, chisels (natural state), die blocks, shear blade, drill steel (solid and hollow). In charge of exhibit: C. O. Sternagle, W. H. Duley, J. H. Jagoe, N. B. Hoffman.

**COLUMBIA TOOL STEEL COMPANY**—Tool steels, alloys entering into manufacturing of steel, tool steel ingots. In charge of exhibit: G. C. Beebe, C. C. Wilhelm.

**CRUCIBLE STEEL COMPANY OF AMERICA**—Special cold drawn shapes and specialties, cutlery steels including stainless steel, a wide range of tools and dies made of Rex AA high speed steel, also intricate dies made of "Paragon" oil hardening steel, a general line of finished products made from Crucible Steel Company steel. In charge of exhibit: J. D. White, O. F. Carl, J. F. Taylor, E. R. Mills, Andrew Schatke, C. A. Palmgren, John C. Woodward, Fred Baskerfield, F. B. Hillwick.

**DARWIN & MILNER, INC.**—Specialists in high speed steels without tungsten, heat treated fractures and other fractures of steels, muffles made from heat and acid resisting material, tool castings made from tungstenless high speed steel. In charge of exhibit: V. Tlach, president; A. F. Brunck, A. Henderson, Walter Candlin.

**DEARBORN CHEMICAL COMPANY**—No-ox-id rust preventative, cutting and quenching oils. In charge of exhibit: L. C. Sherris, H. J. Loudenbach, F. Horstman.

**DEEGAN SUPPLY COMPANY**—Carbon combustion apparatus, hydraulic testing machine. Chainomatic balance, Desco solenoid, Pyrex chemical glassware, burrets, chemicals, Finkl combustion apparatus. In charge of exhibit: E. J. Weber, president; A. G. Shroeder.

**DENVER FIRE CLAY COMPANY.**

**ELE KEM COMPANY.**

**CHARLES ENGELHARD**—Pyrometers, recorders and indicators, thermocouple mountings, central indicating station. In charge of exhibit: E. S. Newcomb, I. H. Oetjen.

**FEDERAL TOOL AND ALLOY STEEL CORPORATION**—High grade tool steels, Swedish iron, welding wire, drill rod, solid and hollow drill steel, tool steel billets, Sisco machinery steel. In charge of exhibit: Thomas Towne, E. Lindeblad.

**FINKL & SONS CO., A.**—General line of drop forgings from 1½ to 300 pounds; forged and heat treated die blocks, piston rods for drop hammers, shane forgings. In charge of exhibit: C. E. Finkl, A. R. Lane, William Finkl, Fred Finkl, Frank Finkl.

**FIRTH-STERLING STEEL COMPANY**—Blue chip high speed tool steel. Firth-Sterling special tool and die steel, fractures of steels shown at various temperatures, alloys and ferro-alloys used in the manufacturing of steel tools. 'S-less' stainless steel featured with examples in various fruits and acids. In charge of exhibit: Alan Jackman, William Nelson, Jr.

**FERGUSON FURNACE COMPANY.**

**GENERAL ELECTRIC COMPANY**—Tool room furnaces, oil tempering baths, rivet heater. In charge of exhibit: V. A. Hain, E. F. Collins, C. A. Winder, H. Fulweider, George Colman, I. B. Terry, J. Sanburg, F. C. Dauch.

**GILBERT & BARKER MANUFACTURING COMPANY**—Model continuous type heat treating annealing and carbonizing furnace, fuel oil burners. In charge of exhibit: C. T. Brenner, J. H. Keegan, H. H. Parent.

**CLAUDE S. GORDON COMPANY**—Hoskins Electric Furnaces, Bristol pyrometers, Brown pyrometers, Taylor pyrometers, Hoffman oil burners, Niagara oil meters, Gordon steam traps, thermocouples and protecting tubes, firebrick, high tempera-

ture cements. In charge of exhibit: A. W. Anderson, E. F. Larry, R. W. Jackson, C. S. Gordon.

**ROBERT K. GREAVES COMPANY**—High speed tool and alloy steels, (Saben Kerau). In charge of exhibit: R. K. Greaves, Miss Park.

**HEPPENSTALL FORGE & KNIFE CO.**—T. P. Wallace, Margaret Reed.

**HOLZ & CO., INC.**—Magnetic apparatus for determining the mechanical properties of steel, Brinell hardness testing machine, portable Brinell meter, Ericson sheet metal testing machine, photomicrographic apparatus. In charge of exhibit: Herman A. Holz, N. J. Gebert.

**HOSKINS MANUFACTURING COMPANY**—Electric heat treating furnaces, pyrometers, heat resistant castings, multiple recording pyrometer. In charge of exhibit: W. A. Gatward, C. S. Kinnison, C. F. Busse.

**E. F. HOUGHTON & CO.**—Carburizing material, quenching, tempering, slushing and cutting oils. In charge of exhibit: R. J. Gurney, E. J. Graham, J. E. Burns, Cressman, H. G. Lloyd.

**ILLINOIS TOOL WORKS**—High speed cutters, hobbs and reamers. In charge of exhibit: H. C. Smith, president, P. E. Tobin, J. F. Hanks, A. G. Henry.

**INGALLS-SHEPARD FORGING COMPANY**—Forgings.

**INTERSTATE IRON & STEEL COMPANY**—Interstate alloy steels, showing billets in various stages, cleaning up for rerolling into finished products, hot rolled bars, finished products. In charge of exhibit: W. J. MacKenzie, A. R. Jones, Elmer Larned.

**LATROBE ELECTRIC STEEL COMPANY**—Electrite uranium steel, P. R. K. 33, Uranium bits, carnotite ore. In charge of exhibit: J. D. Crowley, Clark, Burns, Moore.

**LATROBE TOOL COMPANY**—High speed drills, bridge reamers, reamer drills and countersinks. L. S. Ewing, Hutchinson.

**LEEDS & NORTHRUP CO.**—Pyrometers showing application of multiple point recorders and the growth from the manually operated central station to the automatic central station with controlling mechanism for automatic regulation of temperature. In charge of exhibit: E. B. Estabrook, G. W. Tall, Jr., H. Brewer, C. F. Randolph.

**LUDLUM STEEL COMPANY**—Seminole steel, practical demonstration of seminoles in driving a ¾-inch Seminole hardened peg through a 1¼-inch cube open hearth (carbon 15 to 25 point) demonstrating toughness of high speed bits. In charge of exhibit: C. V. Luin, J. C. Cran, A. F. Chambers, George H. Becker, Robert Fehr.

**MAHR MANUFACTURING COMPANY**—Mahr calorizer, Mahr furnaces. In charge of exhibit: W. G. Barstow, A. E. Stenzel.

**MAXON PREMIX BURNER COMPANY**—Line of gas and oil burners. In charge of exhibit: R. P. Maynard, W. P. Sisson.

**MIDVALE STEEL & ORDINANCE CO.**—Alloy and tool steels; samples of exceptionally large tools, moving pictures showing machinery operation at Nicetown works and manufacture of Midvale tool steels. In charge of exhibit: G. A. Richardson, H. E. Rowe, Richard Jordan, F. W. Sager, A. R. Stone, H. J. Scheer, John Last.

**MODERN EQUIPMENT COMPANY**—Electric tempering furnace. In charge of exhibit: J. A. Fairfield, H. F. Schoneman.

**MYALL WALLACE COMPANY**—D. C. L. carburizing compound, Cinch steel cement. In charge of exhibit: Paul O. Deeds, P. J. Myall, A. W. Raymond.

**NATIONAL MACHINE WORKS**—High speed furnace, rod end forging furnace, Zander burners. In charge of exhibit: Jack Levy.

**PEOPLES GAS LIGHT & COKE CO.**—Industrial applications for gas burning. In charge of exhibit: William H. Langstreet, J. T. Whelan, Carroll.

**PUBLIC SERVICE COMPANY**—Photographs showing industrial concerns served, exhibited with stereomograph. In charge of exhibit: J. H. Gumz, A. Soltow.

**RODMAN CHEMICAL COMPANY**—"Carbo" case hardening compound. In charge of exhibit: H. Schlachter, H. Perry.

**ROESSLER & HASSLACHER CHEMICAL CO.**—Sodium cyanide, cyanide chloride mixture, R. & H. case hardener, copper cyanide. In charge of exhibit: Walter M. Gager, C. H. Proctor, M. E. Stewart.

**P. H. & F. M. ROOTS COMPANY**—Small rotary positive blowers shown in connection with high speed tool furnace. In charge of exhibit: J. B. Patterson.

**JOSEPH T. RYERSON & SON**—Tool steel and forgings, high speed steel, ingots. In charge of exhibit: G. Van Dyke, R. K. Harris.

**SCIENTIFIC MATERIALS COMPANY**—General equipment for metallurgical laboratory, new Scimatco-Optical bench, new soft sheet metal tester, Silverman illuminator. In charge of exhibit: S. F. Orth, E. H. Fisher.

**SIMMONS-BOARDMAN PUBLISHING COMPANY**—Publishers of "Railway Mechanical Engineer," "Railway Age," "Railway Signal Engineer," "Railway Maintenance Engineer," "Railway Electrical Engineer." In charge of exhibit: J. C. March, N. H. Crossland.

**SIMONDS MANUFACTURING COMPANY**—Crucible high speed and carbon tool steels, electric furnace alloy steels in bars and sheets, metal cutting saws. In charge of exhibit: W. D. Weed, George R. Bird.

**STANDARD FUEL ENGINEERING COMPANY**—High speed steel furnaces, oil tempering bath, photographs of large ovens, forges. In charge of exhibit: J. J. Lynch.

**STEEL CITY TESTING LABORATORY**—Hydraulic Brinell hardness testing machine. In charge of exhibit: H. A. Weaver.

**STRONG, CARLISLE & HAMMOND CO.**—Combination high speed steel hardening furnace with a preheating oven, oil drawing furnace with special hood arrangement for carrying off fumes and waste heat. In charge of exhibit: C. E. Doud, Jacob Weintz.

**SURFACE COMBUSTION COMPANY**—Rivet heaters, oven fur-

nace. In charge of exhibit: W. J. Harris, Jr., A. L. Hollinger.

**SWEDISH CRUCIBLE STEEL COMPANY**—Carbonizing boxes, cyaniding boxes. In charge of exhibit: H. H. Harris, M. W. Kingsley.

**TATE-JONES & Co.**—General hardening furnace for oil or gas fuel; gas oven furnace for high speed steel; case hardening furnace; pumping, heating and regulating system for oil fuel; oil burners. In charge of exhibit: J. H. Knapp, W. M. Monk, A. D. Frydendahl.

**TAYLOR INSTRUMENT COMPANY**—Tycos temperature regulator and thermometer. In charge of exhibit: Mr. Schwartz.

**WHITMAN & BARNES MANUFACTURING CO.**—Drills, reamers, wrenches, and drop forgings. In charge of exhibit: J. C. Scanlon, M. J. Kearns.

**VANADIUM-ALLOY STEEL**—Drills, high speed steels, carbon steels, ferro-tungsten in various stages of development, demonstration of "Red Cut" in lathe. In charge of exhibit: Roy A. McKenna, president; John Lee, O. H. Dallman, McFarland, R. D. Guisewite, W. R. Mau, P. W. Bigger, Lambert.

# Electric Furnace Association Organizes

**New Society Urges Closer Co-operation Between Electric Furnace Designer, Power Engineer and Furnace Operator—H. G. Weidenthal Points Out Increased Demand for Electric Steels.**

The Electric Furnace Association which met in Chicago at the Congress Hotel on Monday, September 22, 1919, brought together some of the foremost electric steel men of the United States and Canada. The purpose of the association is to bring out the superior quality of products made in the electric furnace, and an extremely interesting discussion of this subject occurred.

The Electric Furnace Association is the outgrowth of a meeting held in New York last April which was attended by electric furnace men and at which time it was recognized that there was great need for closer coöperation between the electric furnace designer, the power engineer and those who operate electric furnaces. The association is not an offshoot of any other society and its policy will be to coöperate with all other societies and associations which are interested in electric furnaces or the products of electric furnaces.

There were about 60 present at the meeting and H. G. Weidenthal read a very interesting paper in which he pointed out the great demand for better steel in the automotive industry and indicated the increased demand for electric steel in that field. He recited the great need for greater factors of safety in the vital parts of automobiles, trucks and tractors and showed that the electric furnace would be called upon to supply steel of the proper quality.

In response to a demand for data on electric furnace products the association has gathered together some information in regard to the high quality of electric steel and issued it in the form of a booklet. Those who attended the meeting commended this effort on the part of the association very highly and quite a large number of the booklets were requested from those present. In addition to data on quality the booklet also contains some statistics on the growth of electric steel production.

Among those who attended the meeting were L. E.

Howard of the Simonds Manufacturing Company, L. M. Reed, Haynes Stellite Company, A. C. Jones of the Electric Steel Company, Chicago; W. F. Graham of the Spicer Manufacturing Corporation, E. S. Gardner, Illinois Steel Company; Edward T. Moore, Holcomb Steel Company; F. W. Chapman, of the Standard Steel Castings Company; J. M. Blake, American Manganese Steel Company; A. Trevor Jones, American Steel Foundries; A. H. Miller, Midvale Steel & Ordnance Co.; A. U. Tirbutt, Manitoba Steel Foundries, Ltd.; Mr. Starr, Pettibone Mulliken Company, Chicago, and many others interested in the electric steel industry.

A permanent organization was effected and the following officers elected:

President, Acheson Smith; vice presidents, C. H. Booth, W. E. Moore; secretary, C. G. Schluederberg; treasurer, F. J. Ryan.

The address of the executive office of the association is Postoffice Box 616, Niagara Falls, N. Y.

The next meeting of the association will probably be held next spring in conjunction with some of the national technical societies, and it is probable that a symposium on the subject of power for the electric furnace will be the principal feature of the meeting. This will give an opportunity for the power engineer and the electric steel men and others operating electric furnaces to thoroughly discuss the power service problem of the electric furnace.

Although the present meeting was largely devoted to electric steel, it is the intention of the association to take up the subject non-ferrous metals and other materials made in the electric furnace.

The founding of such an organization is highly commendable and should result in much mutual benefit to the manufacturing of electric furnaces as well as to both the producer and the consumer. It is to be hoped that considerable valuable data may follow as a result of the organization of this society.



# Electrical Engineers Convene in St. Louis

**Electrical Problems of the Iron and Steel Industry Discussed. Association Presents Exhibit of Manufacturers as Feature of Convention—Reports Indicate Increase in Membership of Society.**

The Association of Iron and Steel Electrical Engineers held their thirteenth annual convention September 22 to 26, at the Hotel Statler, St. Louis, Mo. Approximately 250 members attended the meeting. On Monday morning, the first day of the meeting, the association elected the following officers: President, B. W. Gilson, Carnegie Steel Company, Youngstown, O.; first vice president, H. C. Cronk, McKinney Steel Company, Cleveland; second vice president, F. A. Wiley, Wisconsin Steel Company, South Chicago, Ill.; directors, W. S. Hall, Illinois Steel Company, South Chicago, Ill.; C. E. Bedell, Wheeling Steel & Iron Co.,

Iron and Steel Industry," (joint paper) "Inspection and Operation of Electrical Apparatus," J. A. Morgan and J. J. Booth.

"Educational Training for Electrical Employees,"

B. A. Cornwell.

"Electrical Repair Shop," C. A. Menk.

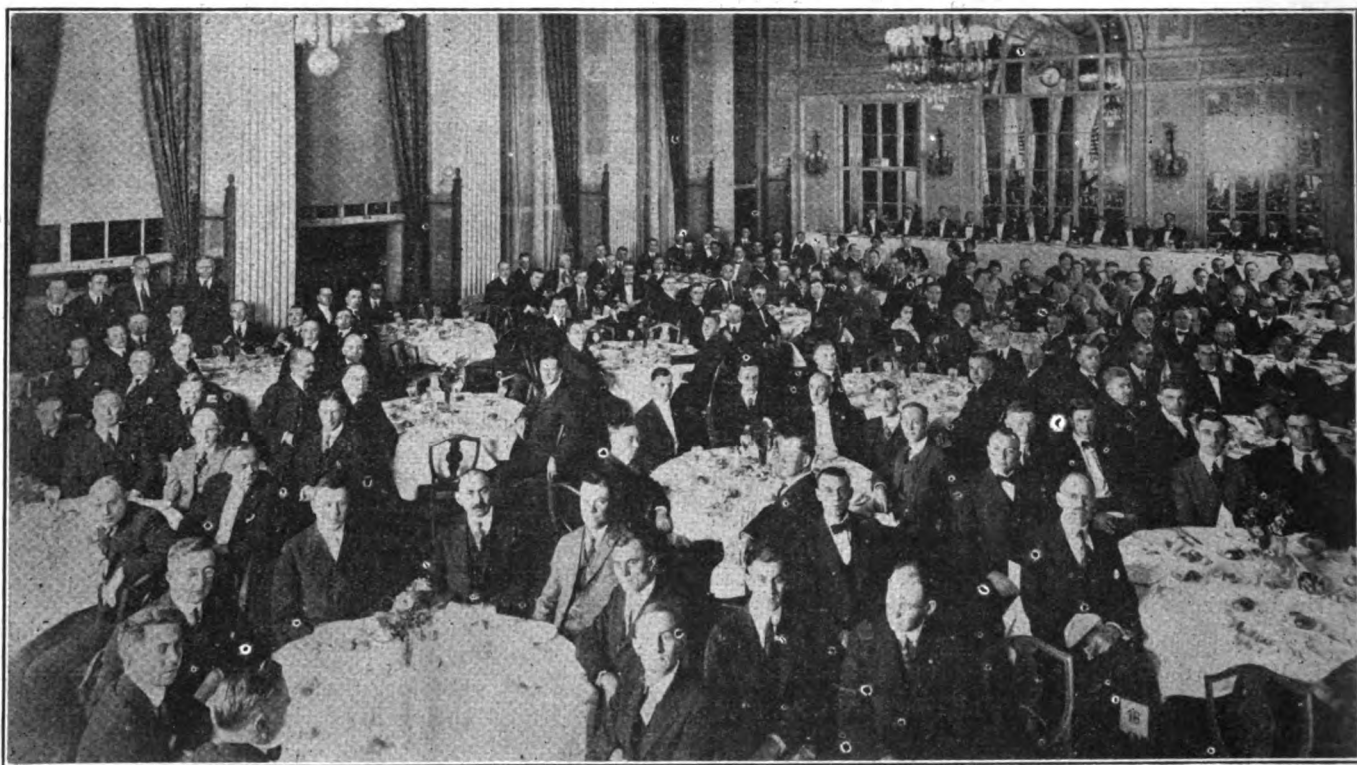
"Storeroom and Spares," T. E. Tynes.

"Records and Tests," R. B. Gerhardt.

"A. C. vs D. C. Motors for Rolling Mill Table Drives," W. S. Hall.

"Recent Improvements in Industrial Control," H. D. James.

"Present Status of Electric Furnaces in the Steel



Association of Iron and Steel Electrical Engineers banquet held in St. Louis.

Wheeling, W. Va.; J. E. Fries, Tennessee Coal, Iron & Railroad Co., Birmingham, Ala.; and R. F. Gale, Midvale Steel & Ordnance Co., Philadelphia; treasurer, James Farrington, LaBelle Iron Works, Steubenville, O.; secretary, J. F. Kelly.

The technical program of the papers prepared for this meeting was as follows:

"Educational Committee Report," Chairman A. B. Holcomb.

"Safety Rules for Government of Employes Working on Electrical Equipment," by safety committee chairman, Walter Greenwood.

"Organization of the Electrical Department in the

Industry," by electric furnace committee chairman, R. D. Nye.

"Electric Heat Treatment," C. A. Winder.

"Overload Protection for Motors," Paul M. Lincoln.

"Overload Protection on Cranes," A. G. Place.

"General Specification for A. C. Motors for Main Roll Drive," by standardization committee chairman, T. E. Tynes.

"Present Status of Arc-Welding in the Iron and Steel Industry." (joint paper), Wilson Welder & Metals Co., A. Churchward; General Electric Company, H. L. Unland; C. & C. Electric and Manufacturing Co., A. M. Bennett; Lincoln Electric Company, R. A. Kinkead; Electric Arc-Cutting & Welding Co., C. J.

Holslag; The Arcwell Corporation, R. M. Rush; Westinghouse Electric & Manufacturing Co., A. M. Candy.

One of the features of the technical session was the symposium on arc welding, the majority of which appears in this issue of THE BLAST FURNACE AND STEEL PLANT. The Wilson Welder & Metals Co. demonstrated the practical application of arc welding as a part of their exhibition.

The annual banquet of the association was held on Wednesday evening, September 24. The chief speeches of the evening were made by the retiring president, D. M. Petty; Philip Stremmel, superintendent of the National Stamping & Enameling Co.; Edgar Gengenbach, industrial commissioner for the St. Louis Chamber of Commerce. D. M. Petty in his speech pointed out some of the purposes of the association, saying in part:

"The keynote of our association is coöperation. The object is the advancement of the application of electricity to the iron and steel and allied industries by the coöperation of its members. The means that have been employed to this end are the presentation and discussion of technical papers in sectional meetings, sections having been formed in Birmingham, Chicago, Cleveland, Philadelphia and Pittsburgh.

"The work done in these meetings, which are held monthly in each city, rapidly is becoming one of the most important phases of the association's activities. One of its greatest advantages lies in the fact that foremen and assistant superintendents can attend these meetings and enter into the discussions, whereas it is impossible for many of them to attend the annual convention.

"The second means to further the art of electrical engineering is referred to as committee work. First the educational committee, which has rendered several reports covering the training of electricians and the men of the mills who handle electrically operated machines; second, the electrical development committee, which is on the lookout for new methods, apparatus of interest to the industry; third, the safety committee, which in 1912 became of such importance that from it the National Safety Council was inaugurated; fourth, the electric furnace committee, and fifth, the standardization committee, which has during the past few years made a strenuous effort to simplify the problems of spare parts for motors, controllers and similar devices.

"The third means by which the association advances the art is the bringing together of the men who are struggling with the problems of increasing production, lowering cost and improving the quality of the product of the plants. The association must help the electrical engineer of the industry do his job better. That we have not failed is shown by the growth of the organization."

Philip Stremmel spoke on "Safety and the Great Advance Made in Steel Plants Throughout the United States Within the Last Three Years."

One of the features of the convention was an exhibit presented by numerous manufacturers of electrical equipment. A list of the exhibitors, the products exhibited and the men in charge of the exhibit appears in the following:

## Exhibition

**AUTOMATIC RECLOSING CIRCUIT BREAKER COMPANY, THE**—Automatic reclosing circuit breakers and protective devices. In charge of exhibit: Mr. Hinkle.

**BENJAMIN ELECTRIC MANUFACTURING COMPANY**—Line of industrial lighting equipment, porcelain enameled steel reflectors, Benjamin-Starrett panel boards, industrial signals, marine fittings. In charge of exhibits: M. J. Cleary and E. A. Detrick.

**BUSSMAN MANUFACTURING COMPANY**—Line of renewable and non-renewable cartridge fuses, plug fuses, auto fuses, open fuse material. In charge of exhibit: H. Bussman, F. E. Lauderbach and A. E. Arthurs.

**BROSUS, EDGAR E.**—Working models of single hook, automatic and wide opening scraper type buckets; single hoist open hearth charging machines, single hoist bullet charging machines. In charge of exhibit: D. W. Allen.

**CHICAGO FUSE MANUFACTURING COMPANY**—Renewable and standard fuses. In charge of exhibit: M. Mill, C. C. Lafferty and E. Greinfeld.

**CROUSE-HINDS COMPANY**—Motor starting switches, safety switches, welding plugs and receptacles, line of "condulets" flood light projectors, industrial vapor proof lighting unit. In charge of exhibit: H. Kei, J. Winnot and R. H. Cook.

**CUTLER-HAMMER COMPANY**—Type M dc magnetic brake for steel mills, type RS ac motor operated brake, crane controller with removable heads enabling lifting of cylinder, traveling cam machine limit, single speed mill master butt contactors. In charge of exhibit: J. U. Heuser, N. L. Mortenson, T. E. Beddoe, R. I. Maujer, E. B. Fogelson, Horter, F. H. Oberschmidt, T. Towie, H. Eastwood.

**DELTA STAR ELECTRIC COMPANY**—Unit type bus bar supports, disconnecting switches, protective equipment for indoor and outdoor service, complete outdoor substation. In charge of exhibit: A. Alasker and E. S. Stickle.

**ECONOMY FUSE & MANUFACTURING Co.**—Fuses. In charge of exhibit: Mr. Fuller and Mr. DeCoursey.

**ELECTRIC CONTROLLER & MANUFACTURING Co.**—Dinkey controller. In charge of exhibit: A. C. Dyer and F. R. Fishback.

**ELECTRIC PRODUCTS COMPANY**—Wotton battery charging rheostats.

**FITTINGS COMPANY, V. V.**—Line of conduit fittings and safety switches. In charge of exhibit: P. H. Schaum, W. L. Rader and G. L. Gaup.

**GENERAL ELECTRIC COMPANY**—Mill type motor, type MD 105, 230 volts, 50 hp, 475 r.p.m. series motor. Photographs of installations. In charge of exhibit: W. B. Bingham and Mr. Baker.

**GENERAL DEVICES & FITTINGS Co.**—Disconnecting switches, bus bar supports, porcelain bushings, conductor fittings, rail supports, low voltage clamp insulation supports, pipe rack fittings, construction devices. In charge of exhibit: J. H. Milliken and C. A. Bird.

**IRON & STEEL EQUIPMENT Co.**—Calebaugh carbon brushes, Lintern crane track sanders, Acme crane safety limit, automatic safety car couplers, Ohio electric lifting magnets. In charge of exhibit: A. H. Swartz and Charles A. Fine.

**KEYSTONE LUBRICATING COMPANY**—Organ spring automatic grease cups. Venango gravity feed grease cups, grease for mine cars, motors, wire cable and gears. In charge of exhibit: G. W. Hall, Samuel J. Adams, K. K. Busby, George J. Kleinfelter, James Sloss, Joseph Yerkes, C. L. Camp, A. Crissenberry.

**LAKEWOOD ENGINEERING COMPANY**—Electric tractor.

**LUDWIG HOMMEL & Co.**—Sangamo watt hour and ampere hour meters, Wagner-quality motor and transformer Hommel-Lites for industrial lighting. The States Company meter testing apparatus. In charge of exhibit: C. A. Swartz.

**MARTIN ROCKWELL CORPORATION**—Asbestos covered wire and cables. In charge of exhibit: B. H. Ahlers.

**MOLONEY ELECTRIC COMPANY**—New weld steel case transformers, high tension bushing. In charge of exhibit: L. H. Keller and E. S. Stickle.

**NATIONAL CARBON COMPANY**—Brushes, batteries, electrode, flash lamps. In charge of exhibit: Warner Jones.

**NATIONAL LAMP WORKS**—Demonstration of intensity, glare and direction of light, typical units, (Ace, Reflecto-Cap, Dome), R. L. M. Dome. In charge of exhibit: J. M. Ketch, Ward Harrison.

**R. D. NUTTALL COMPANY**—Gear cutter, gear couplings, expansion joint. In charge of exhibit: Mr. Fiske.

**PITTSBURGH TRANSFORMER COMPANY**—Pressed steel case distributing transformers, 66,000 volt anistatic bushing, photographs of installations of mill type transformers. In charge of exhibit: J. B. Harris, Jr., C. R. Lininger, Frank Simpson.

**RELIANCE ELECTRIC & ENGINEERING Co.**—New type T general

service mill motor (both ball bearing and old style babbitt bearing). In charge of exhibit: H. H. Howard, H. N. Hitchcock, H. J. Fisher, E. F. J. Lindberg, B. J. Bollard.

SHEPARD ELECTRIC CRANE AND HOIST—Crane. In charge of exhibit: N. P. Farrar.

SQUARE D. Co.—Safety switches. In charge of exhibit: Mr. Stone.

THERMOID RUBBER COMPANY—Brake lining blocks, discs, friction facing. In charge of exhibit: J. L. Cadwallader, A. H. Randall, Burtis.

TOOL STEEL GEAR & PINION CO. — Forged tool steel gear polished to show depth of hardness, ratchet pinion with hardened bushing, shaft and key, cast tooth rack pinion showing life of 8 1/3 to 1 over untreated steel, hardened pickup plates for Corliss engine. In charge of exhibit: Walter H. Evans, P. H. Conrey, J. P. Biggert.

TRUMBULL ELECTRIC MANUFACTURING COMPANY—Safety switches. In charge of exhibit: Mr. Rankin.

VOLK MANUFACTURING COMPANY—Fuses.

WESTINGHOUSE ELECTRIC & MANUFACTURING CO.—A. C. magnetic contactors (125 to 800 ampere capacity), D. C. magnetic contactors, (85 to 1,250 amperes continuous rating). Cam type contactors (125 to 800 amperes), magnetic controller, complete line of starting switches for induction motors, elements for electric heating ovens for enameling and treating of tool steel, lighting fixtures. In charge of exhibit: A. G. Ahrens, P. B. Stewart.

WILSON WELDER & METALS CO., INC.—One arc (150 ampere) portable welding equipment, welding demonstration. In charge of exhibit: T. C. Barnes, H. Wright, Alexander Churchward.

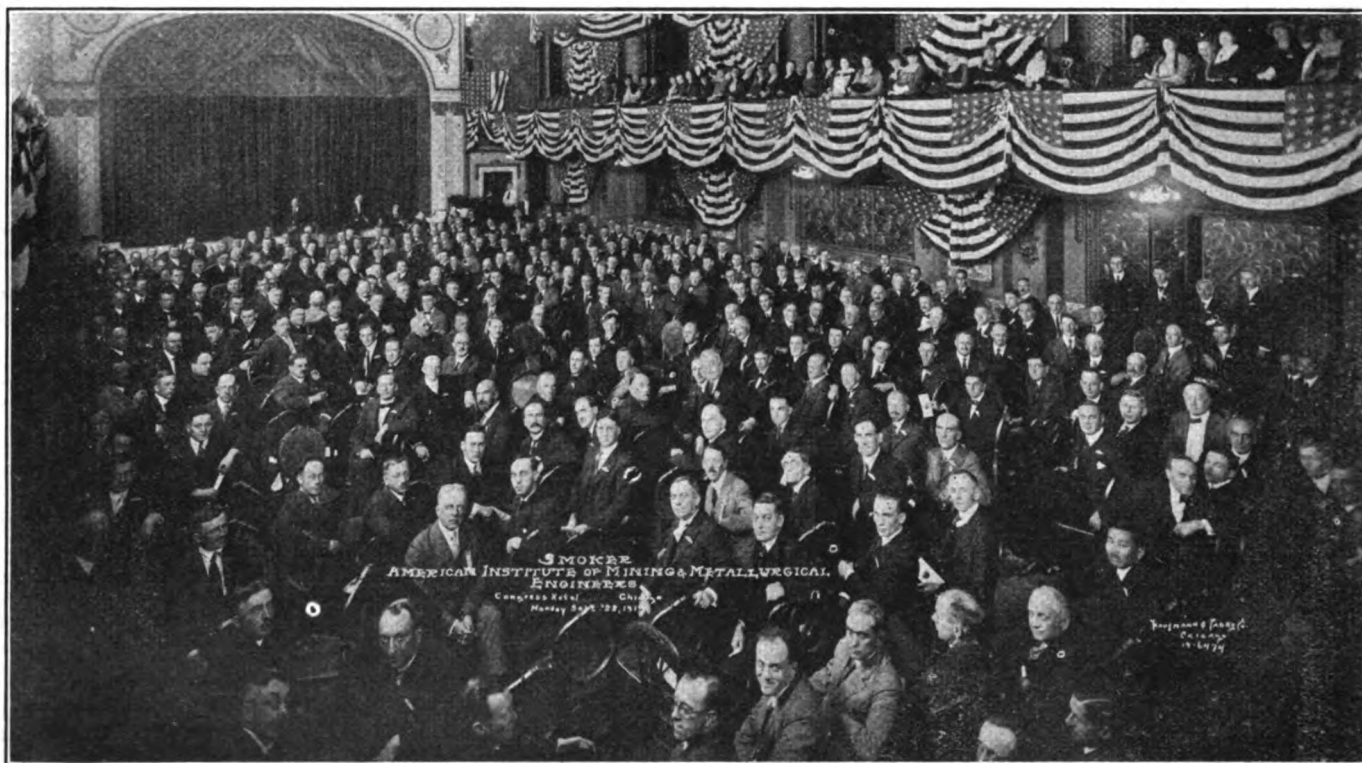
WOODS & LANE CO.—Trico fuses, renewable cartridge fuse.

## A. I. M. & M. E. Discuss Technical Problems

Sessions Present Papers on Non-Ferrous Metallurgy, Coal and Gas, Geology, Mining and Iron and Steel—Symposium on Pyrometry Attracts Attention.

The American Institute of Mining and Metallurgical Engineers held its one hundred and twentieth annual meeting at Congress Hotel, Chicago, September 22 to 26. The meeting was the most important and successful ever held by this society. Exceedingly

of slides shown by Mr. Rice showed the condition of certain steel works and coal mines prior to the war. Illustrations were then shown which showed the condition of the same plants and mines at the present time. Mr. Rice was able to speak convincingly and



Smoker of A. I. M. & M. E. held at the Congress Hotel, Chicago.

comprehensive and valuable technical papers were prepared for this meeting. On Monday night a smoker was held at the Congress Hotel which was addressed by George S. Rice of the United States Bureau of Mines. He described and illustrated by means of lantern slides the tremendous havoc wrought by the Germans in the industrial fields of France. A number

with authority on this subject inasmuch as he was a member of a committee sent to France to investigate the needs for rehabilitating the destroyed industrial centers of Europe.

The annual banquet was addressed by Charles M. Schwab. Mr. Robinson, vice president of the Illinois Steel Company, referred to the steel strike saying:



"It is not a fight for the right to unionize, nor against that right. It is a fight of a militant minority to try to force class distinction upon a peaceful majority."

"It is a conflict upon the result of which will depend, largely whether 4,000,000 organized men shall dictate to 25,000,000 unorganized men how they shall work, where they shall work, or whether they shall work at all. That is not Americanism. It is not true unionism."

With regard to the attitude of the corporation, Mr. Robinson expressed himself as follows:

"The corporation feels the principle of the open shop is vital to liberty of conscience and freedom of action and a benefit to both employer and employee. It believes the country will not stand for the closed shop, because it means decreased production, stunted initiative and high cost of living."

Francis S. Peabody, head of the Peabody Coal Company, a Democratic candidate for United States senator to succeed Senator Lawrence Y. Sherman, was the third speaker.

The following technical papers were prepared for the session on iron and steel:

"Blast Furnace Refractories," by Raymond M. Howe.

"Effervescing Steel," by Henry D. Hibbard.

"Aircraft Steels," by Albert Sauveur.

"Determining Gases in Steel and the Deoxidation of Steel," by J. R. Cain.

"Effect of Time and Low Temperature on Physical Properties of Medium Carbon Steel," by G. A. Reinhardt and H. L. Cutler.

"Erosion Tests of Rifle Barrels," by A. E. Bellis.

"Metallography of Rifle Barrel Steel," by G. F. Butterworth.

"Manufacture of Steel Rails," by Robert W. Hunt.

"The World's Largest Plate Mill," by C. L. Huston.

"Report of Committee on Pyrometry of National Research Council," by George K. Burgess.

"Pyrometry in Blast Furnace Work," by P. H. Royster and T. L. Joseph.

"Pyrometry and Steel Manufacture," by A. H. Miller.

"Electric Open Hearth and Bessemer Steel Temperatures," by F. E. Bash.

"Some Thermal Relations in the Treatment of Steel," by Charles F. Brush.

"Pyrometry in the Tool Manufacturing Industry," by J. V. Emmons.

"Rate of Heating and Cooling of Large Ingots for Forging," by F. E. Bash.

A feature of the convention was a symposium on pyrometry prepared in cooperation with the National Research Council of the United States Bureau of Standards.

## Inter-Allied Foundrymen's Convention

**Twenty-fifth Annual Meeting of American Foundrymen's Associations Held in Philadelphia Outstrips Previous Conventions—Large Number of Exhibitors Show Products—Technical Sessions Held.**

The twenty-fourth annual meeting of the American Foundrymen's Association was held during the week of September 29 to October 4 in Philadelphia. This meeting which is the largest meeting of this association heretofore held is known as the Inter-Allied Foundrymen's Convention and Exhibition. There was an increase of approximately 40 per cent in the floor space devoted to exhibition over that of any previous convention, in that approximately 60,000 square feet were allotted to various manufacturers. In addition to the usual technical session a session was devoted to the discussion of industrial relations. The technical papers prepared for this convention were as follows:

"Considerations Affecting Brass Melting in Gray Iron Shops," by Russell R. Clarke.

"The Weeks Electric Rotating Furnace as Applied to the Brass Foundry Industry," by F. J. Ryan.

"The Need for Coöperative Research in Alloys," by H. E. Howe.

"Audible Signals in Foundries," by Prof. Vladimir Karapetoff.

"How to Secure Best Results in Combining Hoisting Apparatus With Molding Machines," by W. C. Briggs.

"Foundry Sand-Handling Equipment," by H. L. McKinnon.

"Concrete Foundry Molding Floors," by H. H. Haley.

"The Care of Foundry Equipment," by G. L. Grimes.

"Uniform Methods of Cost Accounting," by C. E. Knoeppel.

"Electric Versus Converter Steel," by John Howe Hall and G. R. Hanks.

"Effect of Sulphur in Steel Castings," by Prof. A. E. White.

"Repairing Castings on Transport Northern Pacific," by Arthur F. Braid.

"Comparison of Costs of Electric and Open Hearth Furnace Practice," by E. H. Ballard.

"Operation of the Acid Electric Furnace," by L. B. Lindemuth.

"Values of the Present Methods of Measuring the Temperature of Molten Steel," by F. W. Brooke.

"The Elimination of Strains in Iron Castings," by C. J. Wiltshire.

"The Value of a Scrap Pile," by Henry Traphagen.

"The Electric Furnace as an Adjunct to the Cupola," by George K. Elliott.

Report of the American Foundrymen's Association committee on General Specifications for Gray Iron Castings, Dr. Richard Moldenke.

"Side Blow Converter in Iron Foundry," by George P. Fisher.



"The Testing of Clays for Foundry Use," by Homer F. Staley.

"Cerium in Cast Iron," by Dr. Richard Moldenke.

"Burning Fuel Oil in an Air Furnace," by J. P. Pero.

"The Application of Powdered Coal to Malleable Annealing Furnaces," by Charles Longenecker.

"Efficient Use of Pulverized Coal in Malleable Foundry Practice," by Milton W. Arrowood.

"Powdered Coal as a Fuel in the Foundry," by H. A. Grindle.

"Relation Between Machining Qualities of Malleable Castings and Physical Tests," by Edwin K. Smith and William Barr.

"The Refining of Cupola Malleable in the Electric Furnace," by A. W. Merrick.

"Some Needs of the Malleable Iron Industry," by W. P. Putnam.

"A Note on Britain's Experimental Foundry," by G. Ernest Wells.

"Galvanizing Malleable Castings," by Prof. Enrique Touceda.

"Effects of Annealing Gray and Malleable Iron Bars in Copper Oxide Packing," H. E. Diller.

"Training Men for Foundry Work," by C. C. Schoen.

"Personnel Problems of Modern Industry," by C. D. Dyer, Jr.

"Industrial Democracy and The Foreman," by John Calder.

"Report of the American Foundrymen's Association Committee on Safety, Sanitation and Fire Protection," by Victor T. Noonan.

"Vocational Training for Foundry Occupation," by J. C. Wright.

"The Economical Control and Handling of Patterns in a Large Foundry," by W. D. Jones.

"Progress in the Application of Electric Arc Welding," by Robert E. Kinhead.

"A New Cutting Gas," by Prof. Alfred S. Kinsey.

"Welding Castings of Different Metals and Different Sections," by George B. Malone.

"Report of the American Foundrymen's Association Committee Advisory to the United States Bureau of Standards," by Dr. Richard Moldenke.

"High Temperature Cement for Lining Cupolas, etc.," by W. S. Quigley.

## Organized Industrial Safety Stimulated

### Plant Managers and Safety Engineers Convene to Study Welfare Problems — International Prominence Given to Meeting of National Safety Council by Foreign Exhibits.

The eyes of the industrial world were turned on Cleveland, where 3,700 plant managers, safety engineers, employment supervisors, and other executives interested in accident prevention and the problems of industrial relations met October 1 to 4, inclusive, for an exchange of opinions and experiences at the Eighth Annual Congress of the National Safety Council.

With the country in the throes of a steel strike, the safety congress this year was watched with far more than ordinary interest. Especially in view of the fact that the important subject of employees' representation, and other subjects related to organized industrial safety work, were discussed both by the employers and representatives of organized labor.

At the opening session of the congress discussions of employees' representation were presented by such men as Cyrus McCormick, Jr., works manager of the International Harvester Company, F. L. Feuerbach, factory manager, William Demuth & Co., Richmond Hill, N. Y., and E. D. Tolsted, Independence Bureau, Philadelphia, on the one hand, and Matthew Woll of the American Federation of Labor, Washington, D. C., on the other.

Safety exhibits from far-off Japan, from England, and from Canada, in addition to commercial and non-commercial exhibits from all parts of the United States, were shown in Gray's Armory during the week of September 28 in connection with the Eighth Annual Congress of the National Safety Council.

Though the safety movement originated in England, America has made such greater progress in acci-

dent prevention work that the Britishers now acknowledge the leadership of America in this respect, and are looking to this country for guidance in organized safety work.

Among the exhibits that were shown at the Cleveland safety exposition was one brought to the general office of the National Safety Council at Chicago recently by Baron K. Uchida, former governor of Formosa, Japan, and vice minister of communications of that country, and a member of the National Safety Council of America. The exhibit included pamphlets, posters, bulletins, flags, and other advertising matter used during Safety Week which was conducted in Tokio in June of this year almost identically along the lines of the Cleveland Safety Week. Baron Uchida told C. W. Price, general manager of the National Safety Council, that the idea for Tokio's Safety Week came from the council's report of the St. Louis Safety Week of last year.

It is significant that although this was the first attempt at organized safety work in Japan, Tokio's Safety Week proved to be a "No Accident Week" in fact as well as in name. Tokio has a population of approximately 3,000,000 persons.

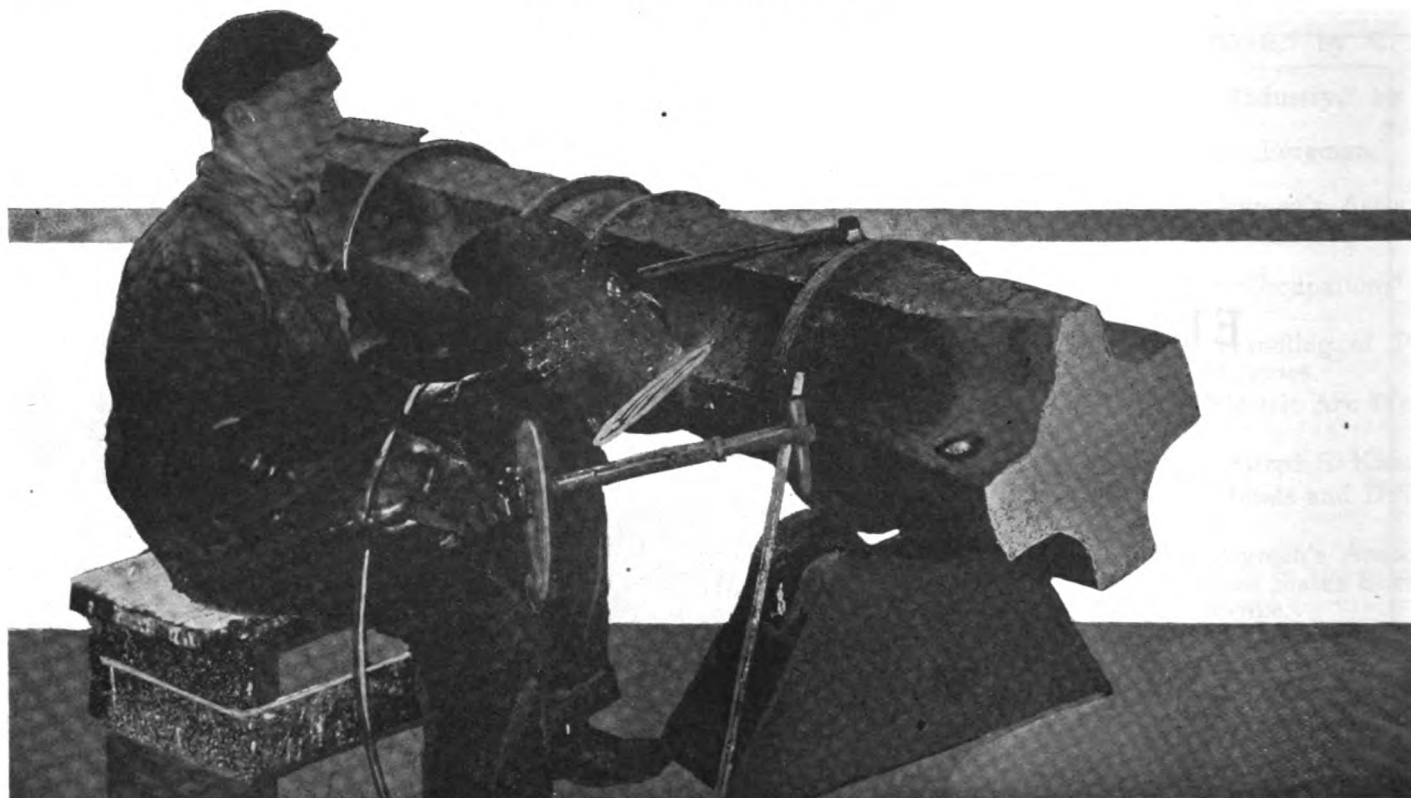
Ralph C. Richards, for a number of years identified with the safety movement through his various offices in the National Safety Council was unanimously elected president of the council by action of the safety committee. Mr. Richards during the first years of the council was a member of the executive committee, a vice president and later was made an honorary member.

## APPLICATION OF ELECTRIC ARC WELDING IN THE STEEL INDUSTRY



*On the following pages will be found a symposium of papers on arc welding which was read before the thirteenth annual meeting of the Association of Iron and Steel Electrical Engineers. Some additional illustrations have been added to these articles to show the practical applications of arc welding in the steel industry. Unless referred to in the text the illustrations were not supplied by the author in whose article they appear. The majority of the illustrations were made available through the courtesy of A. M. Candy, of the Westinghouse Electric & Manufacturing Co., and C. S. Holslag, of the Electric Arc-Cutting Welding Company. The papers comprising this symposium as published in this section are:*

*"The Constant Potential Welding System".....By A. Churchward  
"Arc Welding Equipment for Steel Mills".....By H. L. Unland  
"Constant and Variable Voltage Systems".....By A. M. Bennett  
"Direct and Alternating Current Welding".....By A. M. Candy  
"Special Transformer Delivers Arc Voltage"....By C. J. Holslag*



## The Constant Potential Welding System

Low Power Loss in Line and in Automatic Current Regulation.  
 Low Voltage Insures Short Arc Between Electrode and Work.  
 Importance of Specially Developed Metals Emphasized.

By ALEXANDER CHURCHWARD.

Electricity as a means of joining of metals, in repairing cracks, or breaks, salvaging defective castings and for metal cutting purposes, all included under the general head of electric welding, although comparatively simple in theory, has been slower in development in this particular field than in any other service in which it has been applied. This slow growth is probably due to two causes—the scarcity of skilled operators and reliable apparatus suitable for performing the actual operation.

During the last two years, however, arc welding has made great strides, and undoubtedly a great stepping-stone, by means of which it has attained greater prominence and the confidence of the engineering world in general, was through the successful welding of the damaged parts of the interned German ships at New York at the outbreak of the war in the spring of 1917. The work that was done on the engines of the damaged German ships demonstrated to the engineering world in general that electric welding could be depended upon to make permanent repairs, no matter

how large or bulky the part to be welded, or the character of the metal.

There are four general fundamental types of arc welding outfits in general use, at the present time—constant potential, with fixed resistance; variable potential, rising and falling inversely as the current rises and falls; constant current, all employing direct current, and the alternating current type, with reactive control.

The constant potential system is the oldest of the direct current systems. It was originally designed, to work on a generator voltage of between 75 and 80 volts, but as later experiments and results clearly demonstrated that more satisfactory results could be obtained with a much lower voltage, this system has been redesigned to work on a generator voltage of 35, with 18 to 22 volts at the arc for actual welding.

A distinct advantage of low voltage at the arc is that it becomes impossible for the operator to draw out a long arc between the electrode and the work. The deposition of clean sound metal resulting in a



good weld is largely a question of the operator's skill in maintaining a short and even arc, which eliminates oxidization of the molten metal by the air and insures the metal being deposited in the correct place. The voltage across the arc increases as the arc lengthens, and if the voltage is too low to maintain anything but a correct length of arc, it follows that the operator has a surer indication (when his arc begins to weaken) that he must shorten the distance between his electrode and the work. With a low-voltage supply the external appearance of a weld is a certain guide to its value, and it can be safely reckoned to be free internally from any dangerous slag or oxide inclusions.

In the Wilson system, which comes of course in the constant potential class, the power lost in the line and in the automatic current regulation is of low value compared to the energy actually required for welding and there is, consequently, a great saving over other systems employing higher voltage. The low voltage used also insures better penetration of the original metal by the concentrated arc than is true when a longer, diffused arc of the higher voltage systems is used.

The comprehensive repairs necessary in the case of the damaged engines and other parts of the interned German ships definitely determined that any welding system, to be considered available for such heavy work in cast iron or cast steel, must deliver and maintain a critical degree of heat at the weld, in order to insure proper fusing of the original and the added metal.

This condition is successfully accomplished in the Wilson system, which is in the constant potential class, by means of a standard flat compound 35-volt generator to feed a special constant-current controller. The carbon pile and a solenoid that operates the arc are in series with it, so that the current through the arc is controlled by the automatic variation of the resistance

of the carbon pile in response to the pull of the solenoid. In the early days of arc welding attention was directed solely to developing the machines employed in the operation and very little to the welding metal used, or how it should be used to attain the best welds. The result was that a large percentage of the attempted welds were failures, due principally to the change in characteristics of the welding metal from the effect of the heat of the arc.

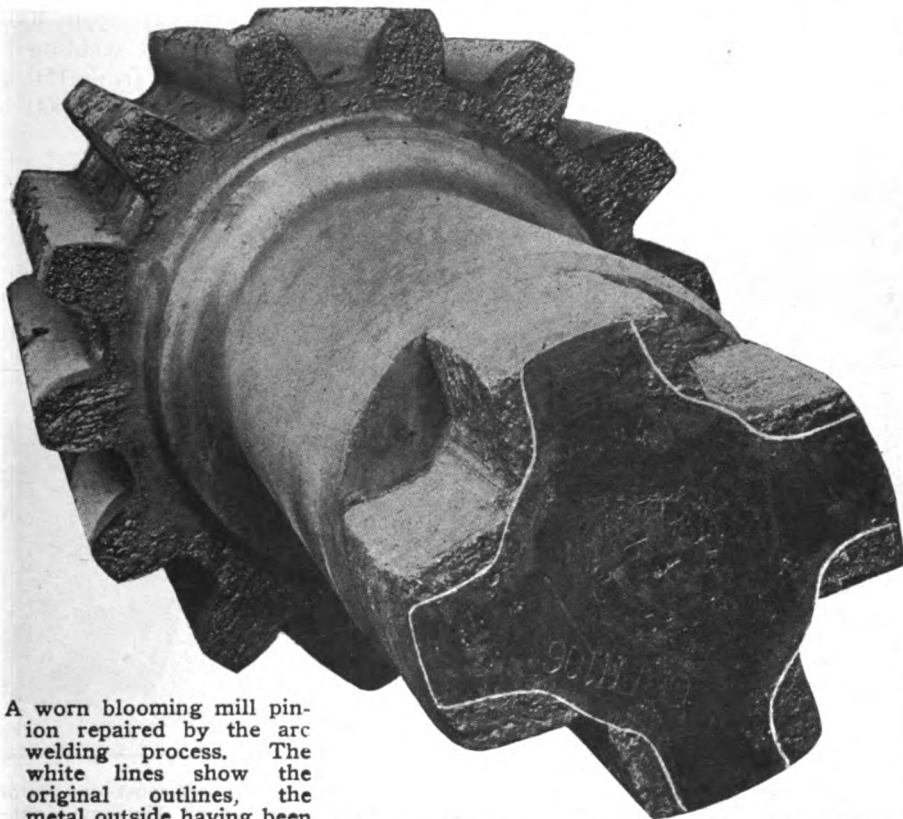
This particular phase of welding was made the subject of special study by laboratory engineers of the Wilson Welder & Metals Co., of 2 Rector street, New York; with the idea of developing a welding metal

that would hold its proper characteristics through the intense heat of the arc. It was determined after long experiment that no one welding metal could be developed that would insure lasting holding qualities in welds on a variety of metals.

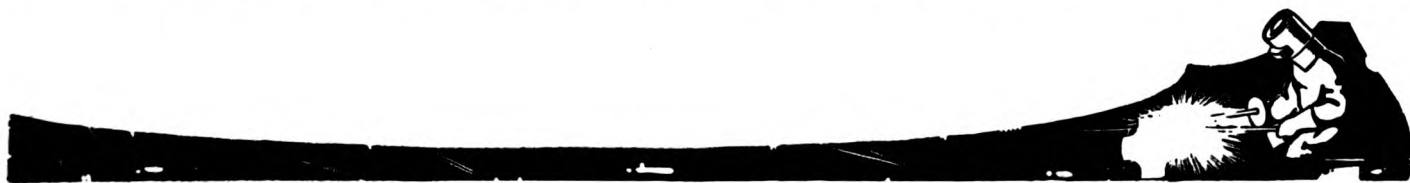
The result was that a number of special welding metals were developed and these were experimented with, analyzed and further developed until the special welding metals, known as Wilson Certified Welding Metals, were finally developed.

In order to insure tensile strength as great as

that of the parent metal, it is absolutely necessary that the welding metal be of such composition as to retain the characteristics of the parent metal after the welding metal has been passed through the intense heat of the arc. In welding parent metal of about 18% per cent carbon and 45% manganese, by the Wilson system, No. 6 welding wire is used. This contains 22% per cent carbon and 75% manganese, with a small amount of copper. Part of the manganese and some of the carbon and practically all of the copper are burned away in the arc, leaving the added metal with about 19% carbon, 50% manganese and no copper, which is approximately the same as the parent metal.



A worn blooming mill pinion repaired by the arc welding process. The white lines show the original outlines, the metal outside having been added. The cost of repairing four ends (two pinions) was \$170. The pinions cost \$1,000 each and could be saved by no other process.





# Arc Welding Equipment for Steel Mills

**Description of Motor Generator Set—Self-Contained Unit, Welding Circuit and Shop Circuit Electrically Independent, Automatic Control Protects Generator—Dial Switch Determines Resistance.**

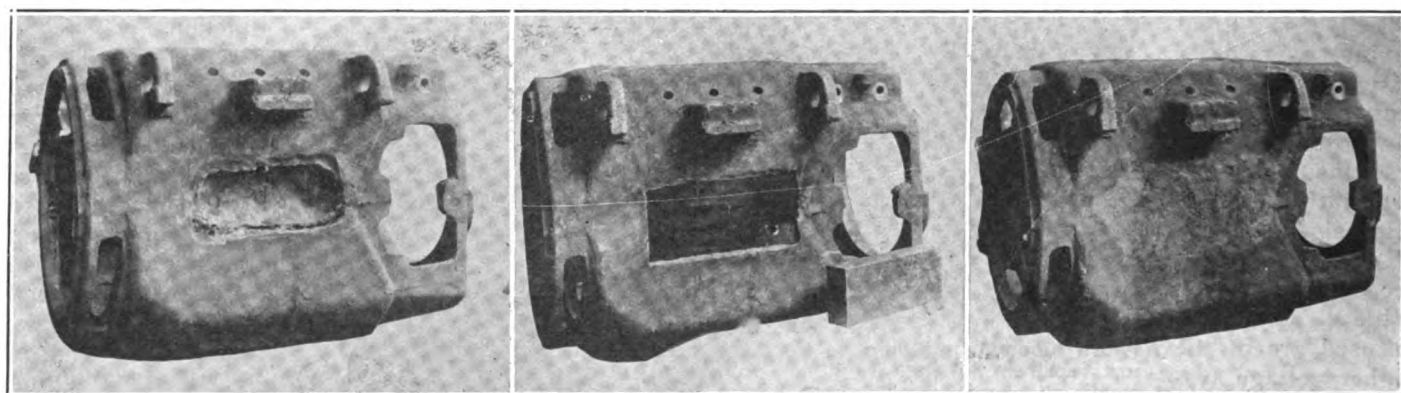
By H. L. UNLAND.

The best all-around type of arc welding equipment for steel mills and foundries is the constant potential type. With this equipment, in addition to metallic electrode welding, it is possible to weld with the carbon electrode and particularly in steel foundries the greater part of the work may be done with this electrode. The advantage of the carbon electrode lies in the fact that higher currents may be used and consequently the metal may be deposited at a much higher rate with the metallic electrode. Also it is possible to cut and to melt off high spots or to clean out sand holes preparatory to welding or filling in.

The General Electric Company has developed a line of low voltage generators especially for this work together with a method of control which gives a very

fine with the shop circuits nor will variations in the voltage of the shop circuit affect the welders. The voltage on the welding circuit can be adjusted, if desired, by the generator field rheostat. These sets are built in various sizes from 400 amperes capacity up to 1,250 amperes. The welding circuit panels can be furnished in capacity from 150 amperes for metallic electrode welding up to 1,000 amperes for carbon welding.

The control equipment consists of a main generator panel with or without a welding control circuit, with a separate auxiliary panel for each operator. In this way several operators may work from one generator, the number depending on the current used as determined by the work to be done. With each welding



**Defective motor frame repaired by arc welding. Extreme left shows sand hole after outer crust was cut off by carbon arc. Center shows defective part ready for welding steel block shown in lower right hand corner. Extreme right shows finished weld.**

good efficiency, combined with flexibility and ample protection. The generator is wound for a voltage of 60 in the smaller sizes and 75 in the larger sizes, and in no case is it necessary to have a generator of higher voltage than this for welding. Lower voltage may occasionally be used with low current values.

The generators are usually furnished as part of a motor-generator set although they can be furnished for belt drive if desired. The motor-generator set is the most desirable equipment for several reasons. It is a self-contained unit, does not demand any attention when running, and the maintenance cost is low. The welding circuits and the shop circuits are electrically independent so that short circuits or sudden changes of load in the welding circuit will not seriously inter-

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The setting of the dial switch on the welding panel determines the amount of resistance in series with the arc and, therefore, controls the current used. This is regulated as required by the work to be done. Before



starting the arc, the operator sets the dial switch for the amount of current required for the work, so that on starting the circuits are in normal running position. Thus there is no necessity for having any relays or switches opened or closed or in any way change or disturb the electrical circuit in order to weld.

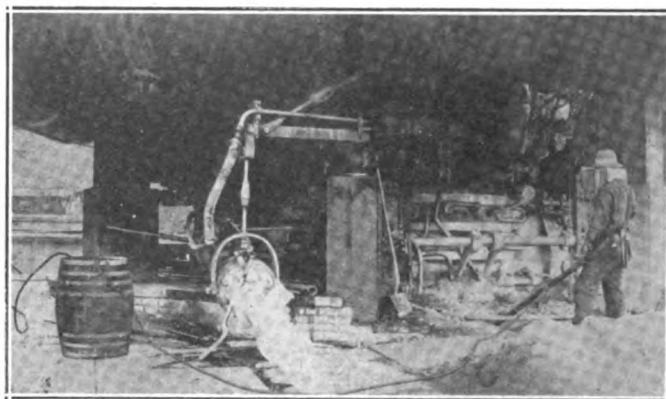
If, however, the operator leaves the electrode in contact with the work too long, or takes too much current after having drawn the arc, the protective relay opens the exciting coil of the contactor which in turn opens the welding circuit. In order to resume operations it is necessary only for the operator to lift the electrode, thereby breaking the circuit, whereupon the relay drops out, closing the contactor and restoring the circuits to the normal operating condition. This system gives complete protection to the generator and assists the operator by making it unnecessary for him to leave his work to close the circuit-breaker, after it has opened due to overload. Other operators, whose welding circuits are connected to the same generator, are not involved in any way since this protection affects only the circuit in trouble. In case of an extremely heavy load or a severe short circuit in the cables, the circuit-breakers on the main panel will open the generator circuit.

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The generator is so wound as to give a no-load or striking voltage of 60 which, when the arc is struck, automatically decreases to the voltage required by the arc. This voltage is from 18 to 20 for average operator and average good work. A longer arc is undesirable since poor work is liable to result. Skilled operators on smooth work are sometimes able to hold a very short arc with a voltage as low as 16, but in rating the generator the value of 20 is used. By adjustment of the dial switch on the panel, the current may be adjusted from a maximum of 200 to a minimum of 75 in 25-ampere steps.

Belt driven generators are mounted on standard sliding bases, and the control panel is arranged for separate mounting. The standard motor generator sets are assembled complete with the control panel on a structural steel base so the entire equipment may be picked up by a crane and handled as a unit. It may be supplied as a portable unit by having running gear bolted under the base frame.

The construction of these sets is the well known General Electric design with long life and low maintenance costs. Standard parts are used as far as possible and no delicate or light mechanisms are used. The bearings on the standard sets and belt driven generators are of the waste packed type to reduce bearing inspection and trouble to a minimum. The connections are simple. Motor leads are brought out at one end and welding leads at the other. It is only necessary to bolt on the required length of cable.



Clogged tap hole in blast furnace being burned out by means of electric arc.

With the metallic electrode a short steady arc should be held. The electrode material should be suitable and this can best be determined by trial in the arc by an experienced welder, although chemical analysis furnishes a guide.

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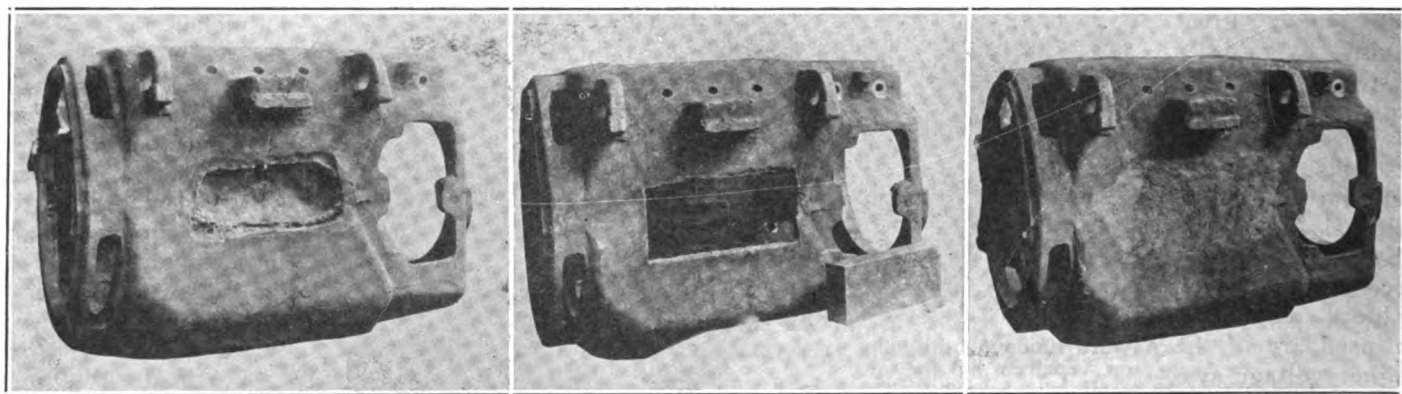
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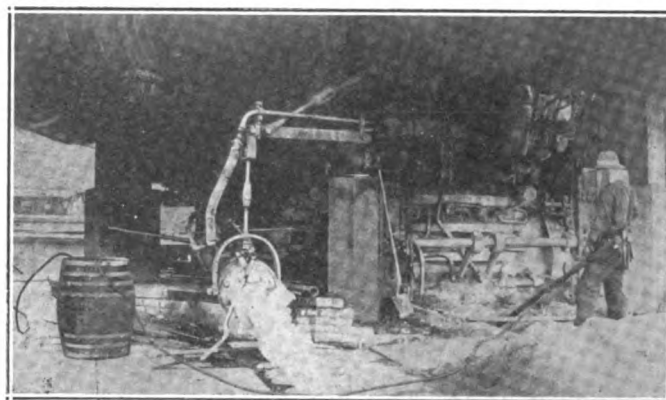
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# Constant and Variable Voltage Systems

**Any Number of Operators Can Work in Multiple from Same Machine Up to Its Capacity When Constant Voltage System Is Used — Variable System Limited to Single Operator.**

By A. M. BENNETT.

All welding systems manufactured by the C. & C. Electric & Manufacturing Co. supply direct current to the arc, and may be classified under the two general types of constant voltage and variable voltage, the latter being the so-called constant current machine.

## Constant Voltage System.

In this system, the voltage at the generator terminals is constant under all conditions of load, and can be varied only by means of the field regulator or other resistance in the shunt field circuit. Machines of this type always work with resistance in series with the arc, this being necessary to steady the arc and prevent current surges of too great value in the arc circuit. The voltage drop in the resistance is the difference between the terminal voltage of the generator and that of the arc.

The terminal voltage is fixed at as low a value as will allow the average operator to be certain of striking the arc, and experience has shown this to be approximately 50 volts. Constant voltage machines are, therefore, for this reason 50-volt machines and their compounding is practically flat over their current range. These machines are all of the interpole type, and in the smaller sizes compounding is obtained through the interpoles. They are built in sizes from 200 to 1,200 amperes, the larger sizes having two commutators.

This type of welder can be driven by any source of power having good speed regulation. It is also built as a dynamotor, combining both motor and generator in one magnet or field frame, in which case there are two windings on the same armature, and two commutators. One side is the motor and the other the generator. This construction is limited to direct current for the motor supply, but in those cases where it can be used it makes a very compact unit, and one costing less than the motor-generator.

This system, as above described, has the advantage that any number of operators can work in multiple from the same machine up to its capacity, without interfering one with the other, and carbon and metallic welding may be done at the same time.

The control for this system has been standardized as a main panel containing the controlling apparatus for motor and generator, and auxiliary welding panels for each operator. Any number of the latter can be furnished up to the capacity of the generator, and

they may be arranged for carbon or metallic work or a combination of the two. By suitable switch arrangements two or more individual circuits may be parallel for heavy work. The arc control for this system is exceedingly simple consisting in the case of the metallic arc, of the resistance and a multiple switch for varying the amount of this resistance in the arc circuit to obtain the required current for welding. For carbon work a contactor is added to introduce additional resistance at the time of striking the arc to prevent series short-circuit on the generator, the action of the contactor being automatic at all times.

While 50 volts is about the least that can be used for striking the arc, it has been found that a steady arc may be maintained on a constant voltage system with a voltage as low as 30, and this has led to development of machines having available the higher voltage for striking the arc, and the lower for working. While these machines also work with resistance in the arc circuit at all times, a saving in energy is effected over that used with 50-volt machines in the ratio of 30 to 50.

One type of this machine is wound for a no-load voltage of 50. As soon as the arc is struck and load is put on the machine, a resistance is automatically inserted into the shunt field circuit by means of a relay, reducing the voltage at the machine terminals to 30, and welding proceeds at this voltage. On breaking the arc, the relay removes the resistance from the shunt field circuit, the voltage is restored to 50 and is again available for striking the arc.

This is necessarily a single operator machine, and is usually furnished in 200-amperes size with motor-generator and panel mounted on a truck for portable use.

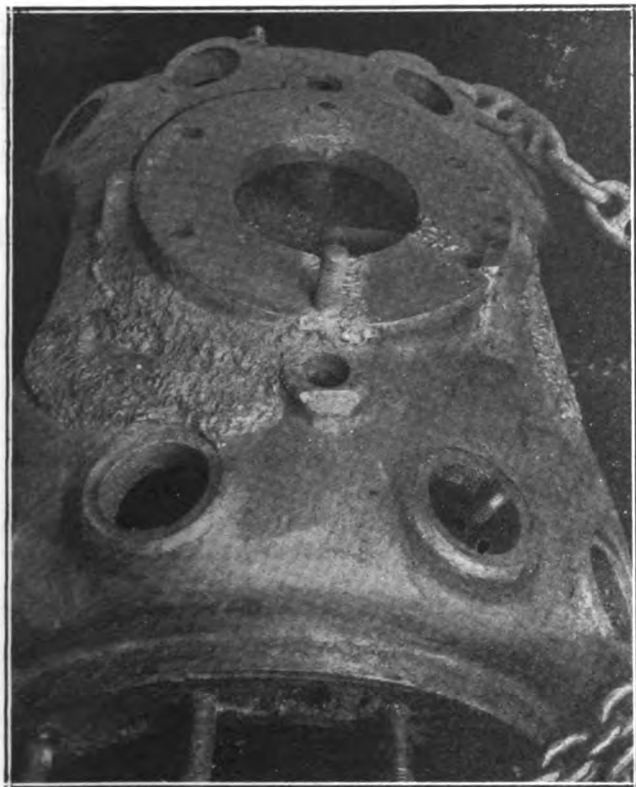
In order to have the advantage of high starting voltage and low welding voltage in a machine suitable for several operators, this company has furnished machines having available at all times both 50 and 30 volts, this being accomplished by means of a double commutator generator, one side wound for 20 volts and the other for 30 volts. These two voltages are placed in series for striking the arc, and the 20 volt side is removed from the circuit by suitable panel arrangement as soon as the arc is struck, and welding proceeds on 30 volts. Inasmuch as these two voltages exist simultaneously any number of operators can make use of them without interfering with each other.



Despite the fact that there is a power loss in the constant voltage system due to the resistance in the arc circuit, there are many good features to offset this disadvantage. In addition to the possibility of working several operators from the same machine, may be mentioned the steadiness of the arc and its extreme flexibility, and the freedom from heavy current fluctuations.

#### Variable Voltage System.

Generators of the variable voltage type maintain at their terminals a potential which varies with the resistance of the arc, the latter depending on the length of arc held by the operator. They are built



Air compressor on which eight cracks were repaired by arc welding.

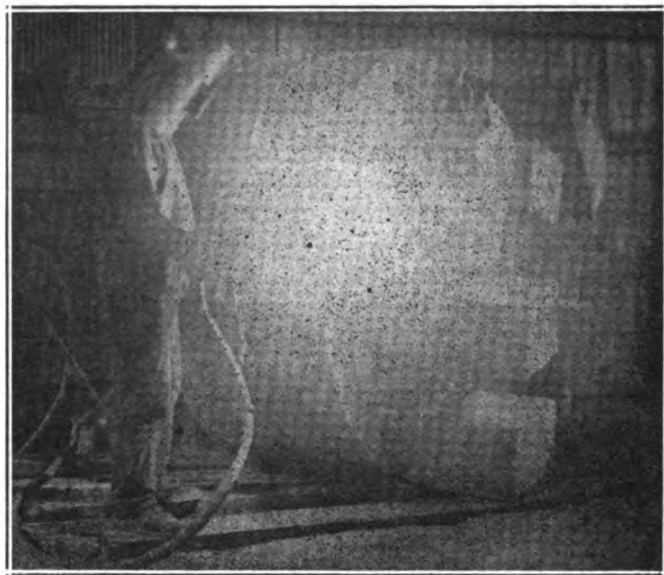
with differentially wound fields, in which the series excitation opposes that produced by the shunt field. On normal welding current the resultant excitation is such as to maintain the voltage and current required at the arc. On rising current the excess of series field excitation bucks down the voltage and brings the current again to normal. On lowering current the reverse action takes place, so that there is a characteristic inherent in the machine always tending to keep the current constant.

Inasmuch as this type of machine works without resistance in the arc circuit, it generates only the voltage required at the arc or approximately 18 volts.

For this reason it is very economical from an operating standpoint. There is no external reactance or stabilizing coil used with this generator, the necessary reactance for steadying the arc being internal to the machine.

Generators of this type have their shunt fields separately excited. With direct current motor generator sets this excitation is obtained from the circuit supplying the motor. Belted outfits and those driven by ac motors or engines have furnished with them a small exciter direct connected to the main generator, which furnishes current for the fields of the latter.

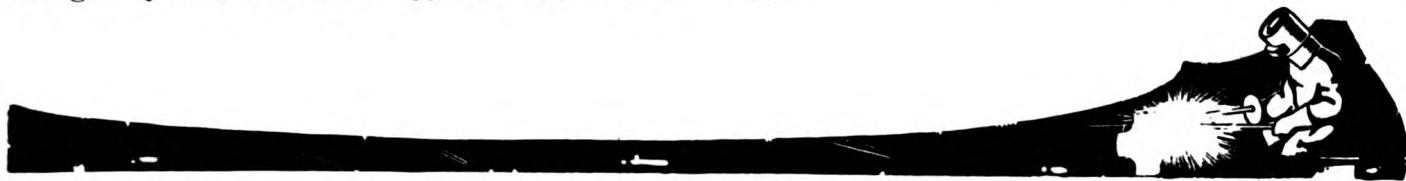
Machines of this type are limited to a single operator, and are generally furnished in 200-ampere size and of the portable type. The same machine can be built for carbon or metallic work though both arcs cannot be used simultaneously. When a two-operator outfit is wanted, two generators driven by a single motor are mounted on the same base. The output from the two generators can be paralleled for carbon work.

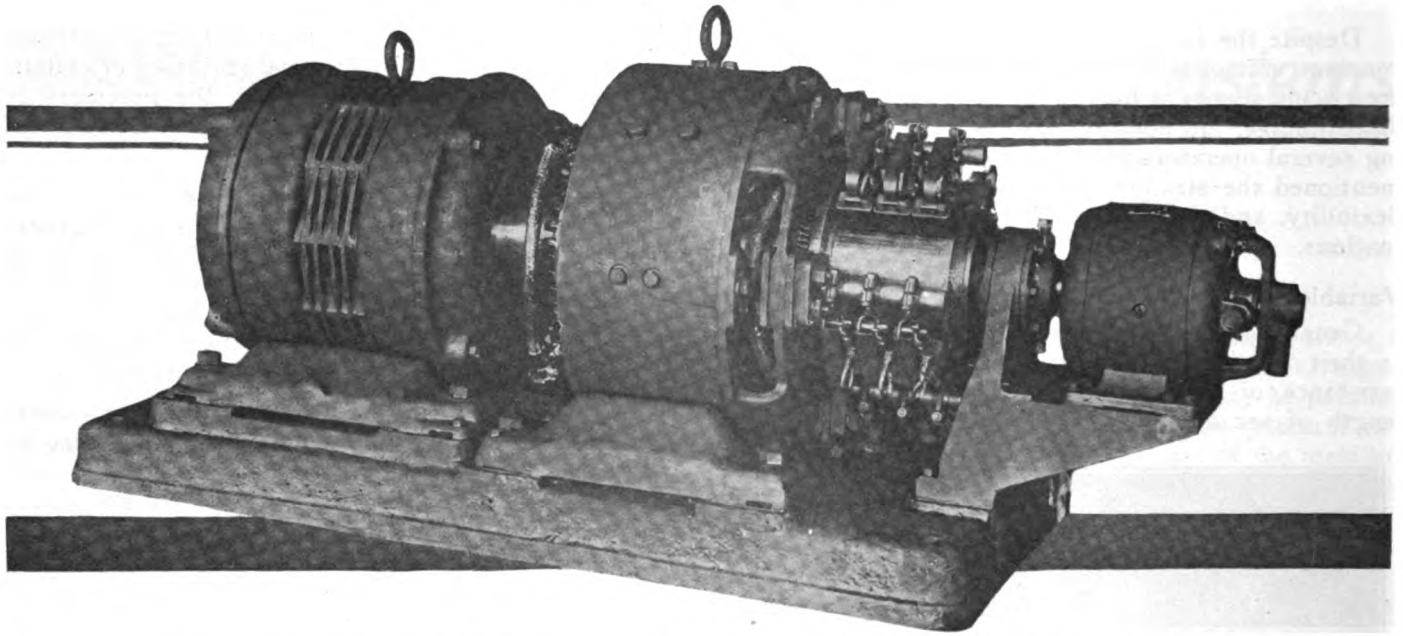


The electric arc being used to remove sinker heads from castings.

The panel arrangement is very simple, consisting of the usual motor control with a line switch and current regulating switch for the generator. The arc from this type of machine is very flexible, and current surges are reduced to a minimum by the inherent reactance of the machine itself.

EDITOR'S NOTE—The two illustrations shown on this page although not included in the author's paper, have been added to show additional interesting applications of electric arc welding. The illustration on the left shows a remarkable welding repair job on an air compressor. Eight cracks were welded on this job.





## Direct and Alternating Current Welding

Reactor Employed in Addition to Resistance When Metal Electrode Is Used—Operator Chiefly Responsible for Successful Weld—General Welding Principles Which Must Be Observed.

By A. M. CANDY.

Although the use of the electric arc for depositing molten binding or filler metal has been known for over 30 years, the recent work of the Emergency Fleet Corporation's welding committee has awakened the industrial world to a realization of the very great economic value of the various electric welding processes. This paper, however, will be confined to the specific subject of electric arc welding.

Briefly, we may define arc welding as the utilization of the intense concentrated heat of the arc for fusing metals so they will commingle and be united when solidified. The electric arc is inherently an unstable electric circuit operating at a potential far below that of commercial transmission systems. It is always necessary, therefore, to install satisfactory electrical apparatus which will provide the proper characteristics for welding requirements.

DC Arc Welding—Until quite recently only direct current has been used for arc welding service, therefore, we will discuss dc apparatus before considering alternating current equipment. For this service there are two general types of equipment available known as single operator and multiple operator outfits. The single operator equipment comprises a motor generator set and control apparatus which can be mounted on a small industrial truck for portable service. The

motor for the set can be provided for any of the usual commercial transmission circuits, of either direct or alternating current of such customary potentials as 550-440-230 volts. The generator, however, is one of the latest and most efficient designs for arc welding service. This machine, due to its unique design and construction is unusually satisfactory for supplying power direct to a welding arc without the use of any stabilizing resistance in the circuit. The unique volt-ampere characteristic of this generator is illustrated by Fig. 1 which indicates the characteristics when operated at three different current values namely, 110, 150 and 190 amperes. The generator is actually capable of operation over a range of 80 to 200 amperes, the various current values are obtained by simply adjusting the field rheostat in the separately excited field circuit. In the case of an ac to dc set the exciter provides the separate excitation, however for a dc to dc set the separate field of the generator is connected to the motor circuit so that the exciter may be omitted. Fig. 2 is an exact reproduction of an oscillographic record showing the arc voltage and current characteristics in actual welding service.

As the name single-operator implies it is only possible for one operator to use this type of a generator at a given time. The chief field for such equipment therefore is where there is only sufficient work





for one welder or where the work is scattered over considerable territory. In the latter instance the installation of several single operator sets either stationary or portable will reduce investment charges due to eliminating long circuits of heavy copper.

Multiple operator equipments, comprise motor generator sets having sufficient capacity to supply current to several welding circuits at one time. The generator of these outfits is a standard compound commutating pole type developing a potential of 60 volts. To control the generator a standard generator control panel can be used or a standard combination generator control and welding control panel may be supplied. The wiring diagram of this panel including

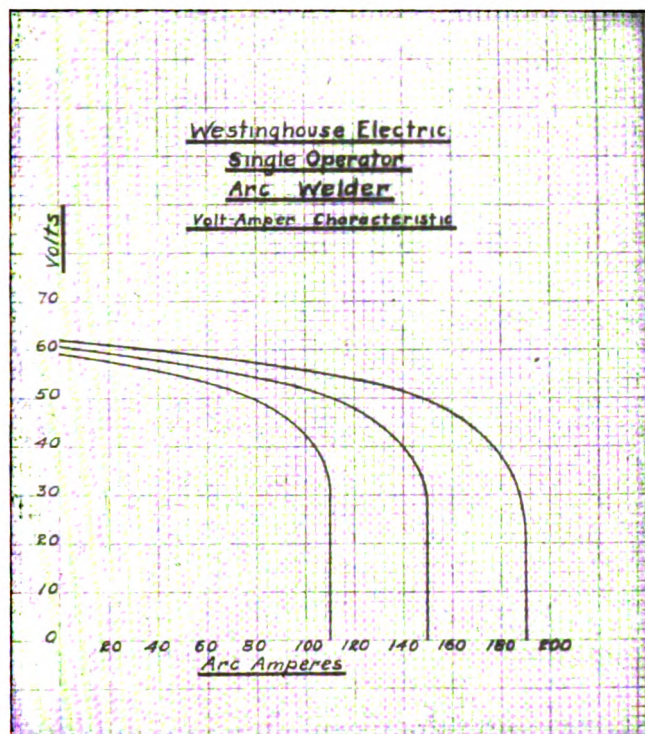


Fig. 1.

the control or ballast resistance is indicated by Fig. 3. One two-pole switch forwarded to control the welding circuit for the panel; another is a feeder switch for a bus line to which one or more welding circuits or outlet panels may be connected. The resistance connected to the single pole switches and in series with the electrode holder serves two purposes namely, (1) stabilizing the arc and (2) providing a means for varying the current. It is obvious that when the single pole switches are closed a number of parallel paths are provided so that an increased current is available.

For welding circuits deriving power from a constant potential circuit of 60 volts or lower we find it desirable to employ a small reactor in addition to the resistance when the metal electrode is used. The

reactor greatly minimizes the tendency for the electrode to fuse to the work which is commonly known as "freezing." The action is briefly as follows: With a 60 volt line and a 20 volt arc we have about 40 volts across the resistance which allows a certain current to flow for welding. However when the operator touches the electrode to the work to strike the arc there is very little voltage drop between the electrode and the work therefore at that time the voltage across the resistance will be increased from 30 volts to possibly 58 volts. As a result the current flowing will be about 45 per cent higher than the welding current. Therefore if the electrode is left in contact with the work even only momentarily it becomes fused and sticks. When the operator pulls the electrode away from the work the reaction frequently results in moving the electrode so far that the arc is broken. As a result the operator will frequently strike his arc two or three times before finally holding the arc. Now if a small reactor is connected in the circuit it will choke or throttle the current so that it will not build up to the maximum value so rapidly and therefore the operator can establish his arc before the electrode sticks.

There are some applications where the weight of a portable single operator set (1150 lbs.) makes it somewhat undesirable. For such installations a small portable outlet panel entirely self contained can be used where a 60 volt circuit of sufficient capacity is available; the net weight of the panel being about 250

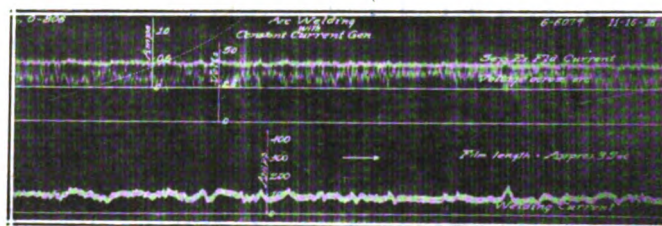


Fig. 2.

pounds. The scheme of connections and the current values obtainable are indicated by Fig. 4.

AC Arc Welding—When attempting to develop apparatus for alternating current arc welding we find that the problem is in some respects more difficult of solution than in the case of direct current. This is due to the fact that, the ac arc is not nearly as tenacious as the dc arc. In other words every instant when the alternating current passes through the zero value there is a marked tendency for the arc to break. In fact if the current through the arc and the voltage across the arc are in phase so that both pass through the zero value at the same time it is impossible to maintain a welding arc either with the carbon electrode or a bare metal electrode. Covered metal electrodes, however, can be operated under these condi-





tions at current values of 100 amperes and above providing the potential of the supply circuit is at least 100 to 110 volts.

To enable an operator to maintain an alternating current arc, easily, with a bare metal electrode the apparatus must provide three functions; first, a constant rate of fusion of the electrode; second, proper phase relation between current and voltage; third, the correct operating voltage.

To fulfill the above requirements we have found that, a transformer must be designed for a large leakage reactance and an open circuit potential appreciably higher than the usual direct current potential of 60 volts. In fact for welding currents of 100 to 125 amperes the reactance of the transformer must be about

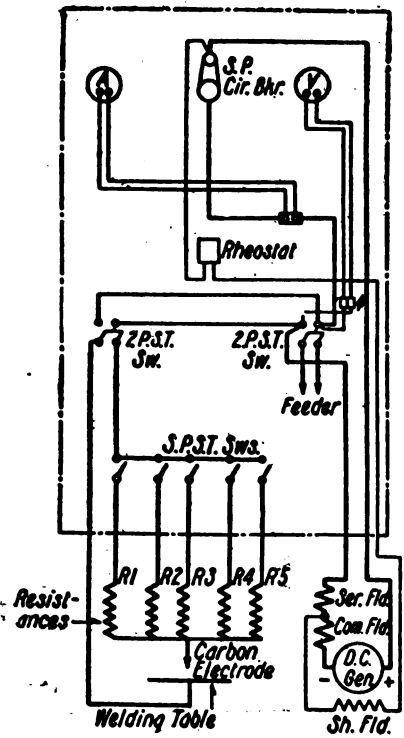


Fig. 3.

98 per cent, therefore the power factor of the welding is about 20 per cent, and the efficiency will be about 80 per cent. On this basis if 175 amperes is used for welding the power taken from the line will be 4.4 kw or 22 kva whereas the single operator direct current set mentioned hereinbefore will take from the line 7.1 kw or 8.25 kva. A transformer of a capacity comparable with the single operator set will have a weight of approximately 450 pounds. Whereas the single equipment will weigh about 900 pounds total.

As mentioned previously in this paper, the applicability of the electric arc for welding purposes has been known for many years and yet only within the last four or five years has any extensive use been made of the processes. Probably the chief reasons for

the apathy of the industrial world have been the lack of general information as to the proper methods of procedure and application and the promiscuous hazardous application, accompanied by lack of proper supervision and inspection of the work. This status however is being rapidly improved by the publication of data obtained by experimental and research work carried on by a number of manufacturing companies and other organizations.

General Welding Principles—To produce satisfactory arc welds, regardless of particular metal welded,

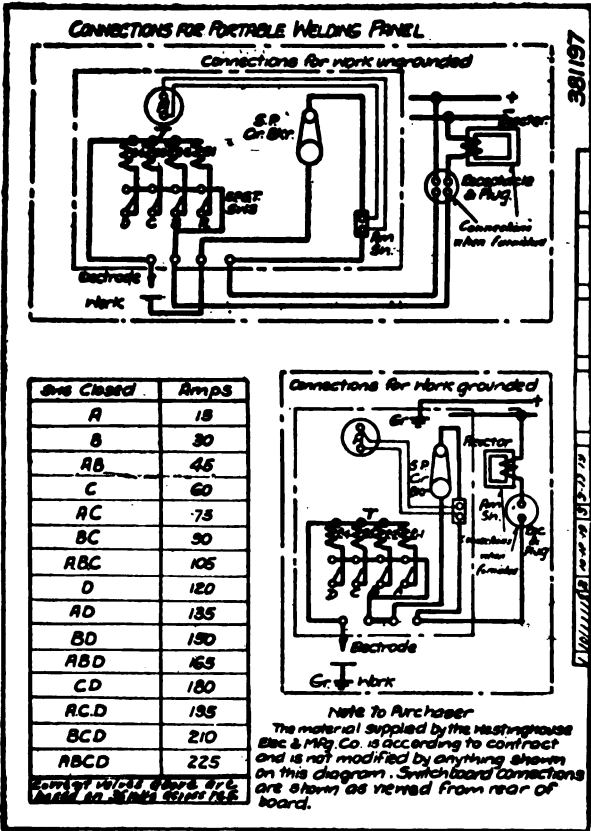
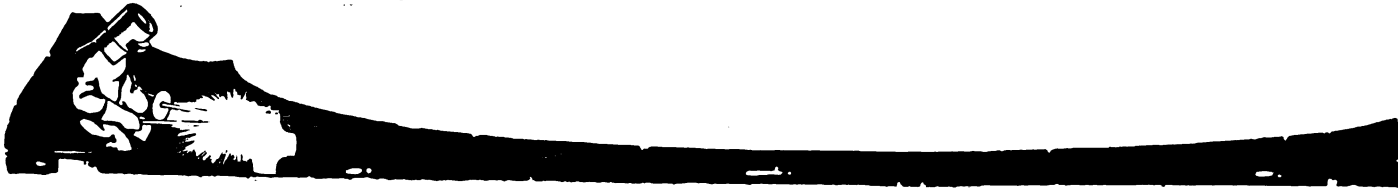


Fig. 4.

there are five fundamental principles, which must be observed systematically.

1. Proper preparation of material prior to welding.
2. Selection of electrode material having best suited physical, chemical and electrical characteristics.
3. Use of proper volume of current.
4. Maintenance of short arc with the metallic electrode.
5. Proper sequence of tacking and filling.

The success of the welding work depends upon the operator conscientiously fulfilling these requirements therefore many authorities evaluate the operator as being 90 per cent responsible for satisfactory welding results.



# Special Transformer Delivers Arc Voltage

**Small Portable Machine Weighs 260 Pounds—Voltage Increase Accompanied by Corresponding Ampere Decrease Keep Heat Automatically Constant—Arc Dies Out if Held Too Long.**

By C. J. HOLSLAG

Before going into the description of the Electric Arc-Cutting Welding Company machine, Fig. 1, let us first go over a rapid history of arc welding machines.

First, there was the resistance type of control. This was composed of grids with taps for varying the current from a constant voltage power supply. Changes in current were obtained by cutting in or out of resistance. This system gave a rough, inherent regulation in that the drop across the resistance varied with the current, tending to check extreme variations and giving approximately compensating action of voltage across the arc and current through it, thereby tending towards a constant rate of heat.

The second development was the generator control. In this method, the generator was so designed that it attempted to adjust itself to new conditions on quick changes of the arc. These generators required separate exciters, and, in some cases, intermediate boosters for the control of the main generator feed.

Now we come to the latest development in arc welding, which is a special transformer, delivering the arc voltage with the necessary characteristics at the terminals. This transformer is made to meet any ac power supply, voltage or frequency.

To have a good welding apparatus, it should have the following desirable features:

First—That it be capable of making a good weld.

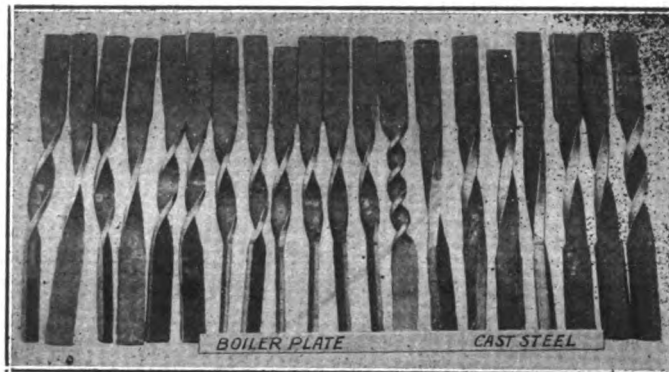
Second—That it be efficient in operation, including not only kw hours required to deposit the pound of metal, but pound of metal deposited per hour; or speed of operation including the cost of labor.

Third—That the cost of maintenance be not excessive.

Fourth—That the cost of wiring for system be not prohibitive.

Let us consider the first feature—good welds. Our machine holds a close arc. Through its automatic regulation of the current and voltage, thereby making it impossible for an operator to hold a long arc through

inattention or carelessness. The general practice for obtaining a close arc is by reducing voltage, but in

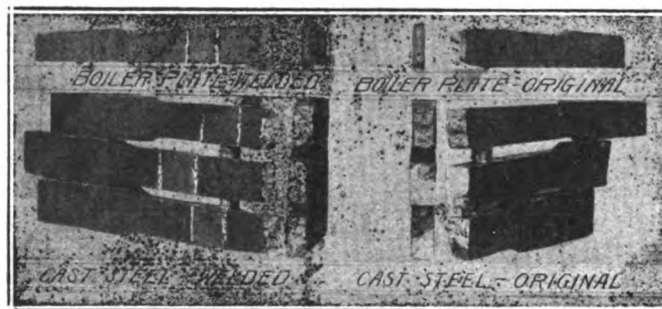


Welded bars under twisting test.

our machines we maintain its high penetrative quality and do not have to reduce the voltage.

All welding experts have decided in order to obtain a good weld the short arc must be held. The expertness and conscientiousness of the operator, as with any machine, provided there are arrangements to limit current, decide, to a great extent, whether or not a short arc is to be held. In our machine, by its automatic and inherent qualities, a short arc must be held, which insures the user that a more perfect weld is obtained.

To return to the features of penetrative quality shown in our welder, we maintain that this is a highly



Welded bars under tensile test.

essential feature because many times in starting the arc or welding, it is necessary to sometimes bite

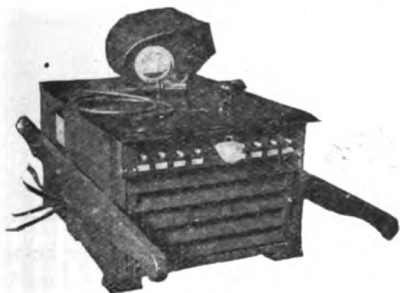
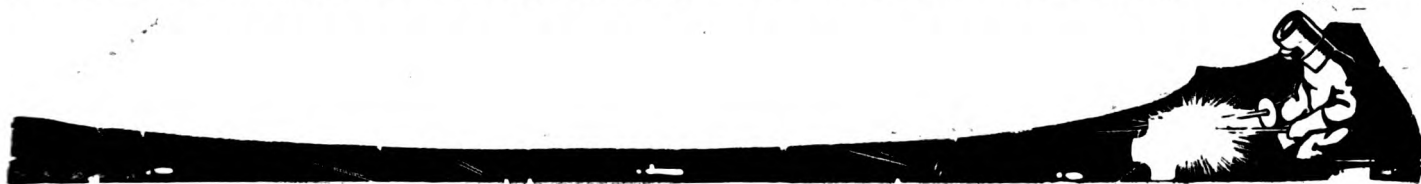


Fig. 1.





through slag, dirt, oil or hard skin of the metal. Therefore, instead of metal being soldered over the work, this high penetrative quality fuses the metal into a deposit of  $\frac{1}{4}$ " or  $\frac{1}{8}$ ", as regulated or needed.

For a given work a definite heat is required, on our machine the larger graduations of current and voltage are obtained by various plugs as shown on the front of the machine, the finer adjustment by moving the flux diverter up or down. After one adjustment to a given condition, this heat is automatically held constant, as rise in volts is always accompanied by a corresponding decrease in amperes or vice versa, making the product of volts and amperes or heat constant. Even with primary voltage variations, our machine counter-balances this effect by means of internal forces in the windings, also keeping the heat of the arc constant. Although this heat be held constant, there is danger of burning, due to the oxidation because of long arc, but, as previously explained, the machine

the unversed and non-technical man, it is often regarded as a close relative of efficiency. In some cases, the terms efficiency and power factor are thought to be synonymous. Power factor is not efficiency.

Power factor in welding runs from 35 to 65 per cent, a fair average being 50 per cent, while our power factor in cutting runs from 65 to 90 per cent, a fair average on heavy cutting being 80 per cent. Our demand for the heaviest welding is 5 kw and for the heaviest cutting is 50 kw. If apparatus were rejected for such power factors, the induction motor would be thrown out, and it is the most widely used piece of electrical apparatus in the world. There is not 1 per cent of all the induction motors that are operating with an all-day power factor higher than 50 per cent.

As this machine is portable, weighing only 260 pounds, there is no difficulty attached to the installation. It is fitted with two handles for carrying around



Welded wobblers. The white lines show how the parts were worn before being welded.

provides for instantaneous dying out of the arc after the arc is held so long as to allow the burning of the metal.

Let me quote an international metallurgist, who says, "There are sound metallurgical reasons why the fusing of the metal to be welded should be done with an agent that is extremely local and extremely hot." This is exactly the result obtained by our welder.

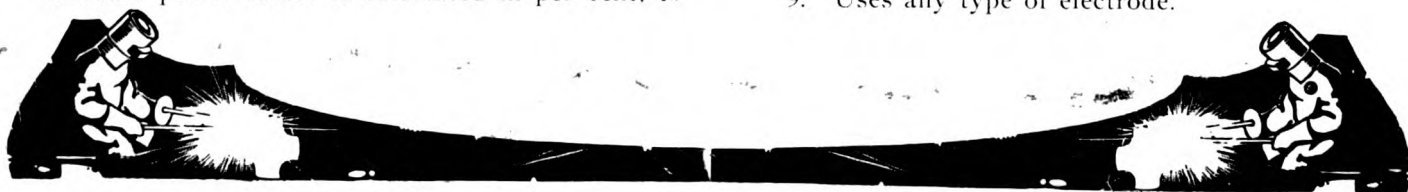
The next feature is efficiency in operation. Efficiency can best be represented over all by the kw hours per pound of metal deposited. In the case of our single change alternating current machine, it takes from  $1\frac{1}{4}$  to 2 kw hours per pound of metal deposited. While not only is it efficient in power required for deposition of metal, another efficiency is shown in the fact that no more current is drawn on short circuit than when in operation. Even when running and not welding, power consumed is less than .2 of one kw.

Because power factor is calculated in per cent, to

to the seat of operation. With this feature, the cost is reduced, as light cable may be used on the primary side and only a few feet of heavy cable is needed on the secondary sides.

In closing, let me renumerate a few of the features.

1. Low first cost.
2. Two kw-hr per pound of metal.
3. Cost of maintenance none. Guaranteed by manufacturers.
4. It is reliable as the inherently short arc insures this. Constant heat is automatically held at the arc.
5. Speed in welding.
6. Portable set.
7. Low comparative cost of installation.
8. Power factor equal to any induction motor generator set.
9. Uses any type of electrode.



# Increasing Primary Cooler Efficiency

Cooler Plate Construction of Corrugated Sheets Suggested to Increase Efficiency of Tar Recovery Apparatus at By-Product Coke Oven Plants.

By GEORGE B. CRAMP.

In the September issue of THE BLAST FURNACE AND STEEL PLANT there appeared a discussion on "Blast Furnace Wet Gas Washer," by the above author. In that article, and in this and following ones, it will be shown that a common principle and a common construction are applicable to all gas apparatus whether for a washing, drying, cooling, heating, absorbing, or distilling operation; and further that the proper application of this principle and construction result in greater efficiency, ease

condensers. This condensation of pitch, however, is but incidental and not altogether desirable, as pitch as it is precipitated within the gas mains, is not sufficiently liquid to drain freely from the mains and the pitch must consequently be dissolved and flushed from the mains by directing a continuous stream of hot tar through them; spooning or scraping at times being necessary to maintain a clean condition of the mains.

Tar being pitch in solution with oils brought down by lower temperature condensation of the gas than that obtained within the gas mains leading from the ovens, is more liquid in consistency and much more easily drained from apparatus in which it is condensed and

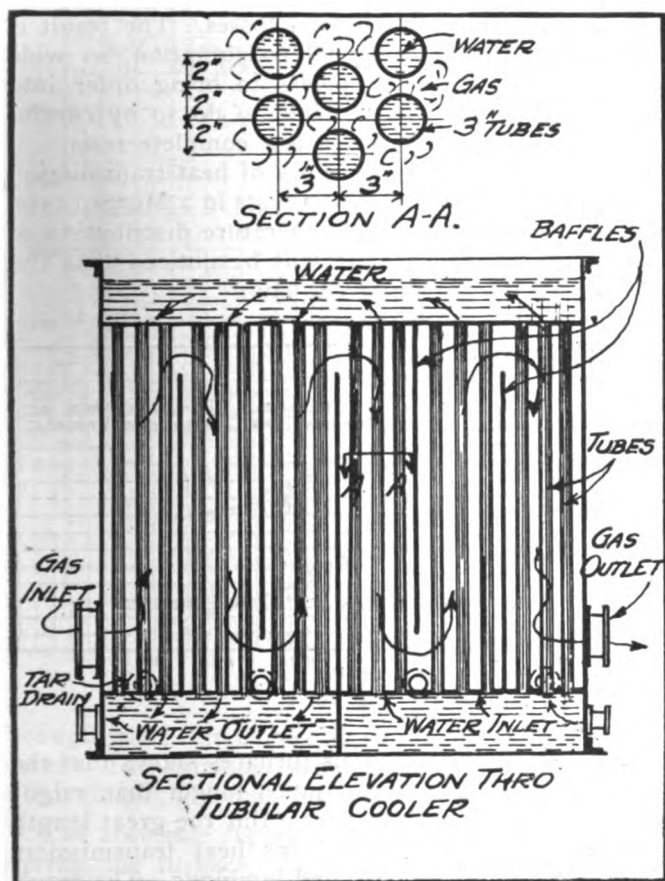


Fig. 1.

of operation and control, as well as a considerable reduction in size of the various apparatus by reason of the more compact construction.

Precipitation of tar in the form of pitch occurs in by-product coke oven gas within the collecting mains at the ovens as soon as the gas leaves the ovens and comes into contact with the atmospherically-cooled surfaces of the gas mains. Pitch is the highest temperature condensate within the gas and is therefore the first to be condensed by contact of the gas with surfaces cooler than that of the gas.

The first step in by-product recovery may, therefore, be said to occur within the gas mains which act as pitch

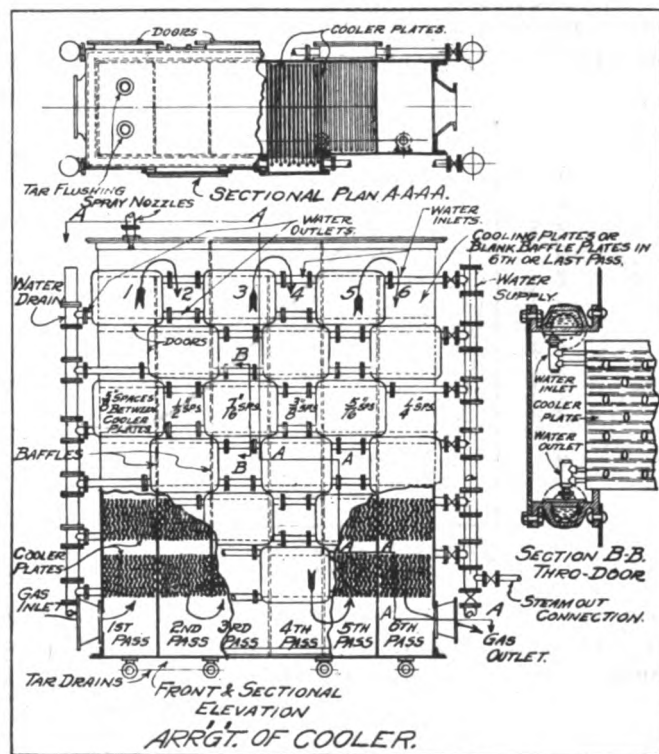


Fig. 2.

precipitated; and separated from the water which is also brought down with the tar by condensation, serves as the flushing medium as described in the foregoing paragraph.

It is within the low temperature condenser or primary cooler—as it is known in by-product recovery practice—that the first positive operation of recovery of the various by-products within coke oven gas occurs. The function of the primary cooler is to cool the gas to the point of yielding by condensation all—if possible—of the tarry vapors and, in consequence thereof, most of the ammonia vapors within the gas; but not the benzol vapors, the latter being removed later in the process of recovery.

(Continued on page 529)

# Heating Furnaces and Annealing Furnaces

**Features Determining the Fuel Economy of Continuous Furnaces.  
Rate of Heat Transmission—Fuel Economy for Best Working  
Conditions and Overall Fuel Economy, Including Mill Delays.**

By W. TRINKS.

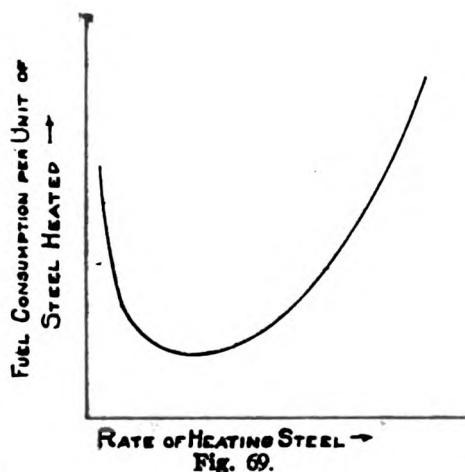
PART X.

The present installment deals with the fuel economy of continuous furnaces. This type of furnace is frequently installed for its labor saving features rather than for its fuel economy, but the latter is a very welcome accompaniment. The labor saving features will be dealt with in a later installment.

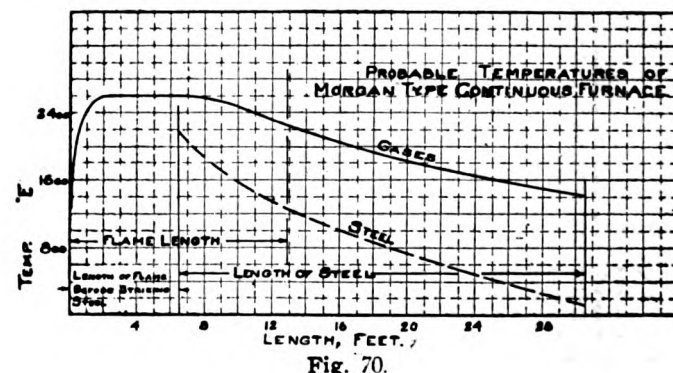
In the continuous furnace, output and fuel economy are very closely related. If much less steel than the rated capacity is passing through the furnace, the stack loss is quite small, because the steel stays in the furnace a long time and can absorb almost all of the available heat from the gases of combustion. On the other hand, radiation losses and convection losses remain approximately the same as before, which means that they are very great per ton of steel. It is, there-

fore, evident that too low an output must be uneconomical. The same is true for too high a rate of working. In that case, the radiation and convection losses are quite small per ton of steel, but the steel passes through the furnace so fast that a very great quantity of fuel must be burned to impart the necessary heat to the steel. The case is similar to that of the reciprocating steam engine, in which too short a cutoff wastes steam on account of too much cylinder condensation, compared to the useful steam, and in which too long a cutoff wastes steam, because the working steam cannot expand far enough.

It is then quite evident that the fuel consumption curve of a continuous furnace will look somewhat like the one indicated in Fig. 69.



An exact calculation of the fuel consumption per ton of steel for a given furnace is very difficult, for the following reasons: Mill operations are very seldom



Observation of continuous furnaces shows that the flame is, indeed, quite long, much longer than might be expected with good burners. But the great length of the flame tremendously helps heat transmission, because the flame is radiant and luminous. The result is that, in continuous furnaces, almost one-half of the

\*The length of flame depends upon the design of burner and upon the mixing of fuel and air at the point of leaving the burner. In the case in question, the fuel is natural gas, and each burner consists of a gas pipe in an air pipe. The so-called theoretical flame temperature, based upon instantaneous combustion, is 3,500 degrees F., while the actual flame temperature probably does not exceed 2,600 to 2,650 degrees. But in the actual flame the hydrogen burns first, bringing the carbon up to incandescent heat, and radiating the latter to the surroundings. The carbon burns gradually in the measure as it finds oxygen, and maintains the temperature of the flame at a fairly constant level. In open hearth furnaces the mixing of gas and air is quite imperfect, and flames of 20 feet length can be observed with natural gas fuel. The effects of illuminants in the fuel will be discussed later on under the heading of "Fuels for Furnaces."



total heat imparted to the steel is imparted in the last quarter of its travel, although the temperature difference between the gas and steel is much greater at the cold end of the furnace than it is at the hot end. In Part I mention was made of the fact that heat transmission at high temperatures is largely accomplished by radiation and that the apparent heat transmission coefficient is, for that very reason, much greater at high temperatures than at low temperatures. Since so much of the total heat is transmitted at the high temperature end, lengthening the furnace for the purpose of increased economy is much less effective than would be expected at first thought.

On the basis of the temperature distribution shown in Fig. 70, on the basis of a test, and of the heat losses

equal weights of steel move over the hearth in unit time. The length of the furnace does not enter into the calculation, much to the surprise of many an engineer; the impression seems to be that a continuous furnace, to be economical, must be long. This is, of course, an erroneous conclusion, because a short furnace may have much less steel pass through it in proportion to its length than a longer one. It must be admitted that the shortening of a furnace cannot be carried on indefinitely, because the furnace will finally become so short that radiation and reflection from wall to wall will cause the temperature to be almost uniform throughout the heating chamber. Likewise, there are limitations to the maximum practicable length of a continuous furnace. If the latter be too long, difficulties arise by buckling of the billets or sticking together of the blooms. For this reason continuous furnaces in excess of 50 feet of steel length are seldom used. Both limitations concerning furnace length are of a practical nature and have nothing to do with the method of calculation here developed. If the calculation results in too long a furnace, the latter must be split up into two or more furnaces of practical length. This proves that the length of a

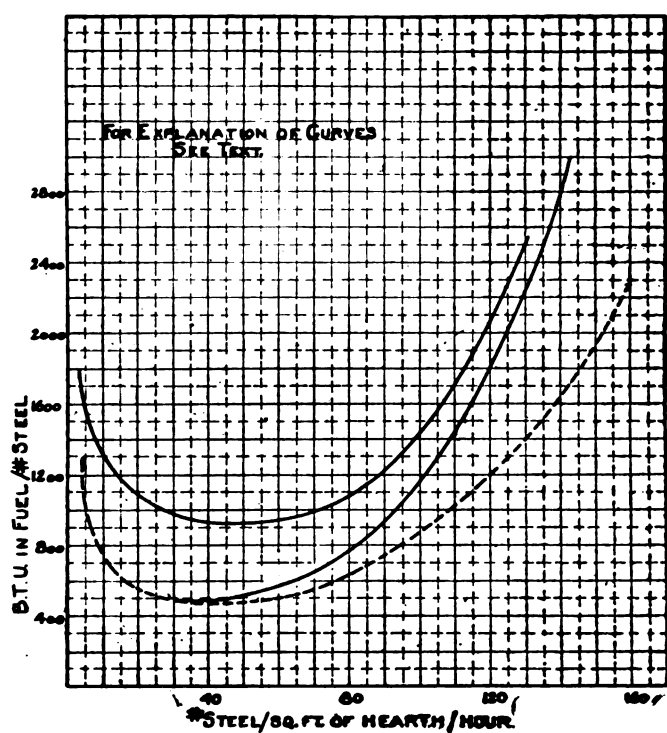


Fig. 71.

through walls, the curves shown in Fig. 71 were computed. The principal difficulty in this work was to select simple, generally applicable units.

The abscissae represent, to some scale, the rate of driving the furnace. In arriving at the scale used, namely pounds of steel per square foot of hearth surface per hour, the following reasoning was used: In a wide continuous furnace (see Fig. 72) the heat given up by the flame has just two places into which to go, namely the surface of the steel and the roof. Most of the heat transmitted to the roof goes back to the steel by radiation, and only a very small part passes through the roof. The roof temperature can nowhere be much higher than the steel temperature, because the roof promptly radiates its excess heat energy back to the steel. Evidently the heat transmission is just the same, no matter how much steel lies under the surface, as long as the temperatures are the same. But the temperatures will be practically the same, regardless of the thickness of the billets or slabs, as long as

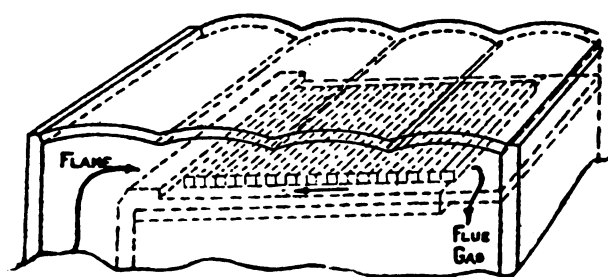
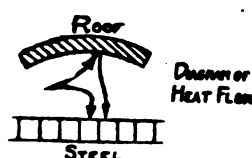


Fig. 72.

continuous furnace does not enter into the fuel economy problem, but that the rate of flow of steel over unit surface and in unit time is the determining factor.

Turning to the ordinates, the problem was to express the fuel economy in a unit which would be applicable for practically every furnace, and for every kind of fuel. First, the difficulty arose to take care of varying thicknesses of roof. Doing so would have meant several curves, lying fairly close together, and making easy reading quite difficult. For that reason, it was decided to limit the present investigation to furnaces with 9 inch roofs. Second, it was deemed unwise to make a curve for every different fuel. For that reason it was decided to plot the fuel consumption in British thermal units in the fuel used per pound of steel heated to 2,200 deg. F. The actual quantity of fuel used to heat a pound of steel can then easily be found by dividing the heat consumption by the heat value of unit quantity of fuel.

A study of the curves in Fig. 71 reveals many interesting facts. First, it will be noticed that the most economical rate of flow of steel lies at about 40 pounds per square foot of hearth surface and hour. Comparison with many furnaces in actual operation shows that only one out of every 10 furnaces is operated at this economical rate, and 60 to 70 pounds is a much more common rate. This is correct commercial engineering, because the difference in fuel consumption between the two rates is small, while the higher rate means a much smaller, and less expensive furnace.

Attention is called to the various curves in Fig. 71. The middle curve is the one which will apply to the majority of furnaces, and gives the fuel expenditure for the heating operation proper, while the upper curve includes the fuel needed under average conditions for keeping the furnace warm during delays, and over Sundays. It also includes the fuel needed for bringing up to working temperature at the beginning of each week. The lowest curve, shown dotted, gives best working conditions and includes the fuel saving due to a good sized recuperator. The latter is, as a rule, used for gaseous fuels only, and is omitted with coal, powdered coal, or oil. As may be expected, the saving due to the recuperator is greatest for those rates of driving for which the flue gases leave with

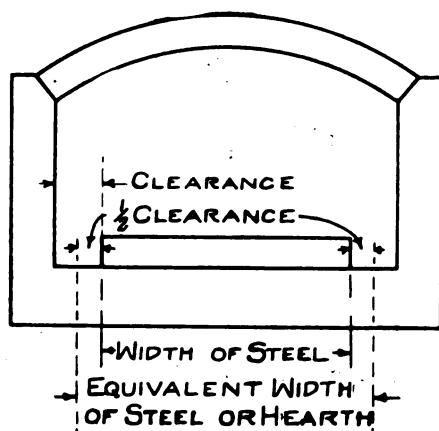


Fig. 73.

the highest temperature. The saving by the recuperator shown in Fig. 71 is based upon a recuperator heating surface equal to 2.1 times the hearth surface.

As before stated, practice shows in many instances a higher fuel consumption than the curves indicate. If the discrepancy in a given case is great, it will be advisable to check up the heating practice and to find out the reasons for the excessive fuel consumption.

An explanation is needed concerning the meaning of the word "hearth area." In a furnace with long billets there can be no misunderstanding, because practically one-half of the transmitted heat goes directly into the steel, and the other half goes to the roof, to be radiated back to the steel. The vacant spaces on the sides and the side walls are, in such a case, quite negligible. It is however quite different with short billets or slabs. Take, for instance, a case as shown in Fig. 73. In this case, much less than one-half of the total transmitted heat passes directly

into the steel from the flame. The larger part of the heat goes into the roof, the side walls, and into the spaces of the hearth between the steel and walls to be radiated back to the steel. Evidently it takes either a long calculation to find the equivalent hearth area, or else a healthy guess, guided by good judgment. To assist in the latter for quick estimates, it will be sufficient to take as equivalent hearth surface the total length of steel multiplied by the width of the steel plus the space or "clearance" on one side. This latter sum has been marked "equivalent width of steel" in the illustration.

The very high rate of heat transmission near the hot end of the furnace results in uneven heating of the steel, if the furnace has to handle heavy billets or blooms. From earlier articles in this series it is known that heat may be transmitted into the surface of the steel much faster by radiation than it can be into the interior of the steel by conduction transmitted with a small temperature difference. This same occurrence appears in the continuous furnace for heavy sections. The top of the steel is very much hotter than the bottom. For that reason the flame is usually split for sections above 3x3", part of it passing above the steel, and part of it passing below the steel. This expedient makes the steel temperature more uniform, but does not make it sufficiently uniform for sections above 8x8", unless the rate of flow of steel is made low or a large soaking hearth is installed. Continuous furnaces for sections above 10x10" are not to be recommended, although one large steel plant has pushed 17x17" sections on skids through a continuous furnace equipped with a large size soaking hearth.\*

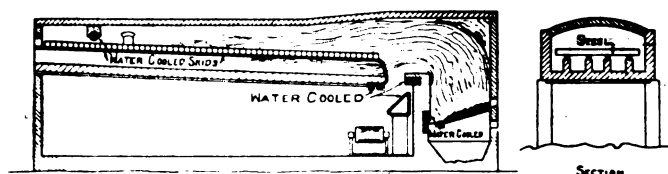


Fig. 74.

A diagrammatic sketch of a split flame continuous furnace is shown in Fig. 74. The question is what effect the splitting of the flame has upon the unit fuel consumption. Apparently, the heating surface is doubled, so that a split flame furnace should, at first

\*The magnitude of the temperature difference between top and bottom of steel in single flame furnaces, or between outside and center in split flame furnaces can be judged from the following approximate figures, which were obtained by a rough calculation based upon parabolic temperature distribution in the interior of the steel, and upon a heat transmission coefficient of 35 Btu per hour, square foot, degrees F., and one foot thickness.

| Size of billet | Rate of steel flow in lbs. per sq. ft. and hour | Size of billet | Temp. diff. deg. F. between center and outside of steel in split flame furnace. |
|----------------|-------------------------------------------------|----------------|---------------------------------------------------------------------------------|
| 8"             |                                                 | 8"             |                                                                                 |
| 12"            |                                                 | 12"            |                                                                                 |
| 75             | 115                                             | 150            | 230                                                                             |
| 150            | 230                                             | 300            | 460                                                                             |
|                | 45                                              |                |                                                                                 |
|                | 88                                              |                |                                                                                 |
|                |                                                 |                | Temp. diff. deg. F. between top and bottom of steel in single flame furnace.    |

thought, be equivalent to a single flow furnace of half the rate of driving. However, tests show that this is not so. The fuel consumption of the split flame furnace is practically equal to that of the single flow furnace for a given rate of steel flow. There are probably two reasons for this fact. First, it is practically impossible to make half of the flame flow above the steel, and the other half below. One of the two passages will always be favored. Second, the split flame furnace requires water cooled skids which are exposed to the flame and absorb a great deal of heat.

All of this discussion applies to furnaces which heat steel to 2,200 deg. F. I have theoretical calculations for the fuel consumption of continuous furnaces heating steel to lower temperatures, but have not sufficient test data to publish them as a guide for others.

A few examples will make the use of the fuel consumption curves in Fig. 71 clear.

1. A furnace fired with natural gas and equipped with a recuperator, is to heat 70,000 pounds of steel per hour from 100 deg. F. to 2,200 deg. F. The furnace is 32' wide, length of steel in direction of pusher motion is 25'. Steel is in the form of bars 4" square, 30' long. How much gas will the furnace use per hour?

Equivalent hearth width = 31'. Hearth area =  $31 \times 25 = 775$  sq. ft. Steel heated per sq. ft. of hearth area per hour =  $\frac{70,000}{775} = 90$  pounds. Since the furnace is equipped with a recuperator we must use the lower curve of Fig. 71. Fuel consumption is equivalent to 750 Btu per pound of steel. If the gas has a heating value of 1,000 Btu per cu. ft., then the fuel consumption is  $\frac{750 \times 70,000}{1,000} = 52,500$  cu. ft. per hour.

2. A coal-fired furnace is designed to heat seven tons of steel per hour. Width of furnace, 11 feet, length of steel bars, 8 feet. Length of steel in furnace, 24 feet. How much coal will be used per ton of steel

including the fuel used during periods of delay?

$$\text{Rate of heating} = \frac{7 \times 2,240}{(8 + 11) \times 24} = 69 \text{ pounds}$$

steel/sq. ft./hour.

From the upper curve 980 Btu are required in the fuel per pound of steel. If the coal has 13,000 Btu per pound, the coal consumption corresponding to this amount of heat equals  $\frac{980 \times 2,240}{13,000} = 170$  pounds/ton of steel.

Coal fired continuous furnaces are always less efficient than gas or oil fired furnaces, however, due to the extra radiating surface of the combustion chamber, its higher temperature, the loss of combustible through the grate, excess air, etc. The actual coal consumption, therefore, would average probably 250 pounds of coal/pound of steel.

3. A furnace fired with producer gas heats 100 bars per hour,  $2\frac{1}{2}$ " square, 10' long. Length of steel in furnace is 31', width of furnace is 12'. (a) What is the fuel consumption per ton of steel when the furnace is working continuously? (b) How much, allowing for delays in mill operation?

$$\frac{100 \times (2\frac{1}{2} \times 2\frac{1}{2} \times 10 \times 12 \times .283)}{31 \times \frac{(10 + 12)}{2}} = 62 \text{ pounds}$$

steel/sq. ft./hour.

From the two upper curves in Fig. 71, the heat in the fuel per pound of steel is 590 for 'a', and 950 for 'b'. With coal of 13,000 Btu, and producer efficiency of 75 per cent,

$$\begin{aligned} \text{a } & \frac{590 \times 2,240}{.75 \times 13,000} = 136 \text{ pounds of coal/ton of steel.} \\ \text{b } & \frac{950 \times 2,240}{.75 \times 13,000} = 220 \text{ pounds of coal/ton of steel,} \\ & \text{allowing for mill delays.} \end{aligned}$$

## Protecting Mill Cranes from Overload

### Fuses, Circuit Breakers and Crane Protective Panels Used for Crane Protection — Recommends Protection of Individual Circuits Rather Than Main Line.

By A. G. PLACE.

It is generally recognized that protection from overloads is necessary to keep the motors in good condition, to keep the wiring from being burned up and annealed, to protect the gearing, shafts and ropes from breaks, excessive strains, cracks and slight breaks that might develop later into the cause of an accident or delay.

In order to quickly locate trouble, no common return wires are used on cranes, but each motor and controller has its own individual circuit from the main switch. Therefore, in order to protect each motor and controller, individual means of protection should be provided on

Paper read before St. Louis meeting of the Association of Iron and Steel Electrical Engineers.

each motion so that the proper sized protector can be used. If all the circuits join together, and are then protected, the protective device often becomes so large that damage can be done by a current which is too small to operate the protective device. This can most easily happen on the circuit of a small trolley cross travel motor, when the protection has to be big enough for a large hoist motor. We can therefore start with the fact that in order to protect each motor circuit, individual protection is needed for each circuit.

To get complete protection from grounds on either side of the line, it is also necessary to protect both sides of the line on each circuit.



There are three methods usually used to protect cranes, fuses, circuit breakers and crane protective panels.

The method of using fuses is the most economical in first cost. It requires a slate or asbestos board panel with a main line knife switch, and a pair of copper strap bus bars from which a pair of fuses lead off to each motor and controller, being designed the right size to properly protect that circuit. There is no need of a main line fuse, as it will not protect from anything but trouble between it and the distributing fuses going to each individual motor. For all ordinary crane service on three or four motor cranes, there is no need of knife switches ahead of each individual circuit fuse, because if a fuse is blown, the main line knife switch can be pulled out to replace the fuse. In special cases it is sometimes an advantage to have a switch ahead of the fuses on each circuit, so that the crane can go right on working while repairs are being made to the one motion which is out of use with the switch pulled out. Usually the individual switches are superfluous, even on cranes that can be used with one circuit dead, because the main line switch can be opened long enough to remove the fuses from any one circuit and thus make it safe to work on and repair.

There are two kinds of fuses generally used, the enclosed cartridge type and the open copper or lead wire type with thumb screw. The first type is used where any danger of fire exists. The second type is used in places where fire danger is not present, such as in a modern fireproof crane cage, with no combustible material in the cage. The open wire type has the advantage of low initial cost and low renewal cost, but must be properly used by experienced men in order to prevent accidental burns.

The use of a circuit breaker for overload protection is quite common and gives very satisfactory results. Upon opening under load, it can be quickly reclosed and the work can proceed with no delay. To get full protection for all motors, would require a circuit breaker on each circuit, as the main circuit breaker would not open on current sufficiently large to burn up all the wiring on the smallest motor. To get full protection from grounds also requires a double-pole circuit breaker for each motor circuit, which would mean an array of circuit breakers that would take up too much of the limited room in a crane cab. Therefore, when circuit breakers are used, they generally consist of a single or double pole breaker in the main line, and only open on heavy currents. Local conditions, such as dirt and vibration, are factors to be considered in breaker installation. Sometimes a breaker operated by a shunt coil is used, the shunt coil then being operated by push buttons, and often being used as a hoist limit stop by a positive opening of the shunt coil line.

The method of using overload relays with a contactor is also very generally used for crane overload protection. Any desired combination to give any desired degree of protection can be installed, such as relay in both sides of the main line only; relay in one side of each motor circuit and in the opposite side of the main line; relay in one side of each motor circuit; or relays in both sides of each motor circuit. With this type of crane protective switchboard, a start and stop push button is used to operate the main line contactor, thus making it possible to locate the push button close to the operator

for emergency use, with the contactor panel located in a more convenient place in any part of the cage. The contactor also opens automatically on voltage failure, and has to be reset by the push button.

Another advantage obtained by the use of overload relay panels is the addition of inverse time element attachments on the overload relays. Equipped in this way a small overload of several seconds duration will trip the overload relay and open the line contactor. Without this attachment, the motor has to stand these small continuous overloads, because the overload relay has to be set high enough to allow for starting currents, and makes no distinction between the instantaneous starting current and the abnormal condition of a continuous starting current. Therefore much better protection can be obtained by the use of the inverse time element attachments.

Considering the three methods of protection outlined above under operating conditions, we find the following troubles: When a fuse blows repeatedly, the natural inclination of the human mind is to make the fuse heavier. On a fused crane switchboard, the fuses may be changed to very heavy fuses in a short time, too heavy to ever give any protection. With circuit breakers and with overload relays, the adjustment is changed to the highest obtainable current in some cases of trouble or extra heavy lifts and is never changed back to the normal setting, thus, giving very little protection. Sometimes the contactors are wedged so that they can not open, or the overload relays are jumped so that they cannot open the contactor circuit, thus giving no protection. Such conditions should never be allowed to exist, but due to the fact that the crane cages are up in the air and not reached except by a special trip, they are liable to get by for some time without discovery. A regular check inspection by the turn foreman or a special crane inspector is necessary to be sure that the overload protection is correct for the crane, as well as to look after other parts of the crane. No one form of protection is any better than any other unless it is kept in good condition.

When overload relays and contactors were first used on cranes, many operating men became prejudiced against them because the vibration of the crane opened the contactor circuits, and because sometimes the collector shoe hit a joint and bounced enough to allow the contactor to drop out and cut off the current. The relays now supplied are free from vibration troubles, and the use of two shoes on each main collector makes sure that the contactor will never open due to collector shoe jumping. The conclusions arrived at from the above are as follows: The amount of protection obtained on a crane depends on the amount of money spent on the protective apparatus.

It is better to protect the individual circuits and not try to protect the main line on a crane. Protection in one side of each motor circuit protects against every condition except a ground on the opposite side of the line.

Cranes protected from overloads have less delays on account of less breakage on ropes, gear teeth, caps and cap bolts, keyways, etc.

No form of protection is of any use unless it is kept in the proper condition.

# A Recuperative Furnace for the Forge Shop

**Recuperators Composed of Rectangular Hollow Refractory Tiles.  
Can Be Fired With Liquid or Gaseous Fuel — Furnace  
Manufactured by H. B. Dempsey Furnace Company.**

In Europe, where high-price fuels prevail much study has been given to fuel economy, and nearly all furnaces are equipped with some means of reclaiming heat from the flue gases. During the war much of the European furnace business that had formerly been enjoyed by England and Germany diverted to America. Naturally our engineers were obliged to acquaint themselves with European conditions and design furnaces that would be acceptable.

The furnace here illustrated is designed for economical firing, it employs recuperators of unique design for reclaiming heat from the waste gases. The flue gases are utilized for preheating the combustion air, the heat thus absorbed being returned to the furnace. Additional economy is secured due to the fact that the fuel can be burned with less excess air when the air is preheated, also oxidation of the charge is diminished.

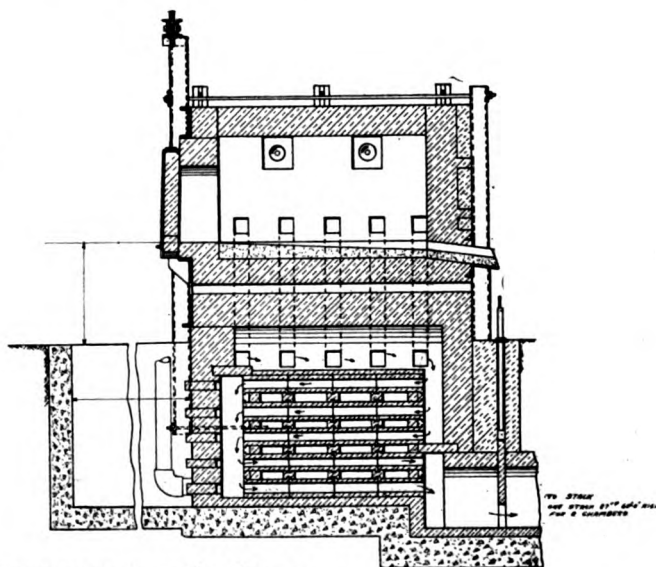
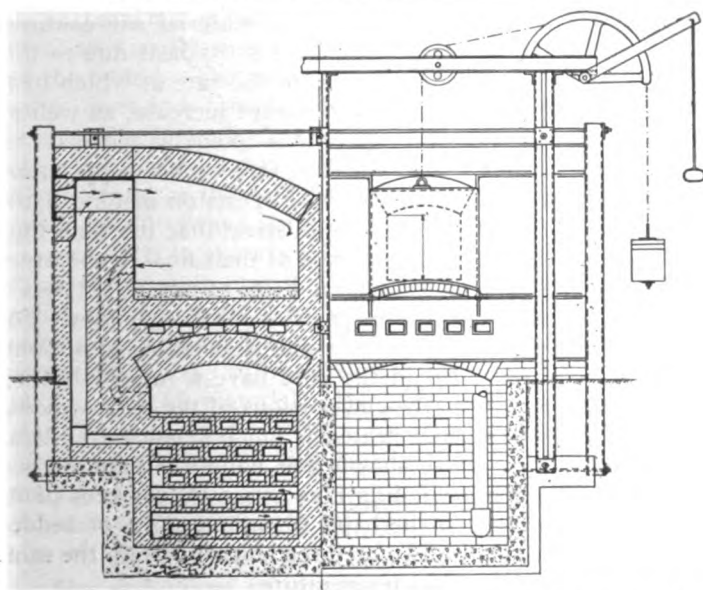
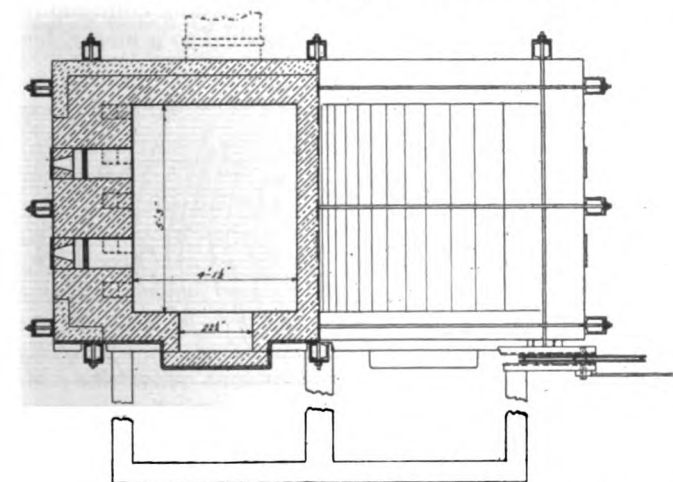
The recuperators are composed of rectangular hol-

low refractory tiles flanged top and bottom, through which the hot flue gases pass on their way to the stack. These tiles are built in tiers and separated one from the other vertically by grooved tiles which serve to lock the joints of the hollow tiles together and also form flues for the passage of the incoming combustion air. This form of recuperator permits a large contact surface area per cubic foot of space occupied.

A recuperative furnace to be advantageous must be durable and low enough in first cost to make an investment in same profitable. The furnace illustrated will resist excessive vibration caused by steam hammers and like machinery, the entire recuperator forming one solid rectangular mass with joints locked together, so that leaks are almost impossible. As the tiles are made of refractory material, high temperatures will not cause injury. The construction being simple the cost of installation is comparatively low.

A reduction of from 15 to 30 per cent of fuel can be realized which is well worth considering. For example, take a plant using only 500 gallons of fuel oil per day. On a basis of 300 days per year and oil at 4 cents per gallon, the cost of fuel per year would be \$6,000. A reduction of 18 per cent in fuel would result in a gross saving of 18 per cent of \$6,000 or \$1,080. From this should be deducted the interest on the money invested, which in this case would amount to about \$150.

The furnace can be fired with any liquid or gaseous fuel, and can be changed from one fuel to the other at a trifling cost. This two-door furnace is a type usually found in the average hammer shop and in practically all railroad forge shops, but the recuperator can be applied to any medium or high temperature furnace having hearth area of 25 square feet or more.



Plan, elevation and section of Dempsey recuperative furnace.

# Preventing Overloads on Steel Mill Motors

Description of Ammeter Depending on Temperature for Its Indications and Having the Same Mass-Ventilation Ratio as the Mill Motor to Be Protected Against Overload.

By P. M. LINCOLN.

In the operation of electric motors driving reversing mills in steel plants—or for that matter with any other motor application wherein the load constantly fluctuates over a considerable range—it often becomes a serious problem to determine whether or not the motor is being overloaded. The object of this brief paper is to describe a means whereby the overloading of such motors may be indicated and prevented.

Motors designed for the operation of almost any steel mill equipment, and particularly those for operating reversing mills, must necessarily be so designed that they can be overloaded, even severely overloaded, for short periods of time without harm. The nature of the work to be performed makes such a design imperative. The work to be done on hot steel as it passes through a mill in the process of being reduced from an ingot to a billet is not uniform, but varies from second to second over a very wide range. To indicate how wide this range of load is in actual practice, reference may be made to Figures 1 and 2. Figure 1 represents the instantaneous

2,500 amperes and it is, therefore, evident that the maximum duty which the motor was called upon to exert was at least  $2\frac{1}{4}$  times the continuous rating.

Figure 2 shows a record about 90 seconds long of the power cycle of a motor operating a reversing plate mill. In this service the duty on the motor is quite similar in character to that of a blooming mill, the motor being a reversing motor and the metal passing back and forth through the mill for a number of cycles. In the case shown in Figure 2 there were 11 passes of the metal through the mill before being finished. The number of passes will, of course, depend upon the character of the plate mill which is being rolled. In the case of the plate mill the maximum current required by the motor rose to about 3,000 amperes, while the continuous rating of the motor was 1,370 amperes. In this case also, the motor was called upon for a maximum duty of at least  $2\frac{1}{4}$  times the duty that it may be expected to handle continuously.

When a given steady load is applied to a motor, heat-

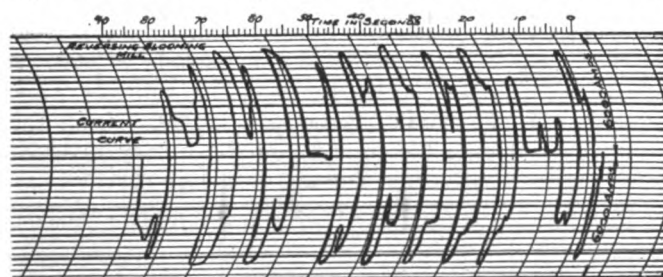


Fig. 1—Instantaneous load variation on blooming mill.

variation of the load on a typical blooming mill over a total period of about 90 seconds. As shown in this particular record, the ingot made 19 passes through the mill before being passed on to the next process. It will be noted that the motor reached a maximum current of about 5,400 amperes and that this maximum was reached on nearly every one of the 19 passes that the ingot made through the mill. The heating effect upon the motor is dictated not only by the average value—or r. m. s. (root mean square) value—of the current taken during the rolling period, as shown on this chart, but is also largely influenced by the frequency with which the mill is made to handle successive ingots. The 19 passes required by this particular ingot were made in approximately 90 seconds and it is during this period that the motor acquires heat. During the rest period between successive ingots, the motor has a chance to cool off and the relative length of the rest period is, therefore, a vital factor in determining the average load on a given motor. In this particular case the continuous rating of the motor was

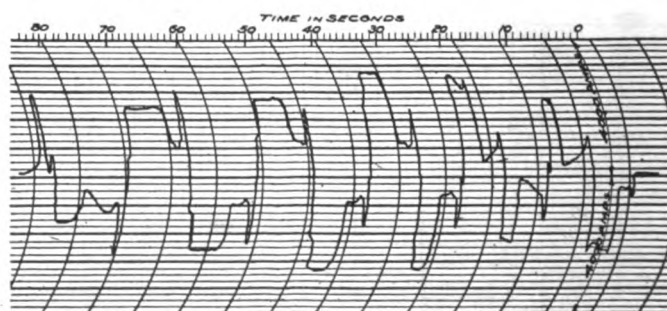


Fig. 2—Power cycle of motor on reversing plate mill.

ing of the motor takes place, but the heating does not take place instantly. If we apply heat at a constant rate to any given mass of material, the material will continue to rise in temperature until the loss of heat due to this temperature rise is just equal to the rate at which heat is applied. The rate of temperature increase, as well as the final temperature attained, is fixed by the mass of material subject to heating, the rate of heat application and the rate of heat dissipation. Tests on motors of the type usually used in steel mills show that the time they require for attaining 90 per cent of their final temperature depends not only on the type and size of motor, but also is not uniform in the various parts of the same motor. For instance, the portions of the armature winding of a motor which are embedded in the core have a rate of heating quite different from the end portions of the same winding where the mass being heated is much smaller. Tests as well as analysis have shown that while the exposed end portion of such a winding may attain 90 per cent of its final temperature in perhaps 30 minutes, the embedded portion may require two or three hours to attain the same proportion of its final temperature.

Paper read before St. Louis meeting of the Association of Iron and Steel Electrical Engineers.



Obviously, an ammeter of the usual type cannot be used to indicate the overloading on equipment which carries a load of the type shown in Figures 1 and 2. An ammeter responds instantly to the flow of current and always indicates the amount of current flowing at the instant of observation. The heating of a motor, however, does not respond instantly to the current which flows. The heating of a motor requires time to take place, the amount of this time varying somewhat with the character of the motor. The time required for any given electrical equipment to attain its final temperature is fixed, as indicated above, by the ratio of the mass of material that is subject to heating and the efficacy of the ventilation that is used to dispose of that heat. In general it may be said that the smaller and better ventilated an electrical machine is, the more quickly will it arrive at its final temperature. In respect to the time of response to heating, electrical equipment varies over a very wide range. Of all standard electrical equipment, the filament of the incandescent lamp is probably the quickest in this respect, requiring only a small fraction of a second to attain its final temperature when a given voltage is applied. On the other hand, a large self-cooled oil-insulated transformer will require more than 24 hours to arrive at 90 per cent of its final temperature rise when a given constant load is applied. As indicated above, the time required by a typical large motor to arrive at 90 per cent of its final temperature rise may be put at perhaps one-half hour as a minimum and often ranges up to two or three hours as a maximum.

The problem to be discussed in this brief paper is that of indicating the heating effect, on a motor that requires perhaps an hour or two to heat, of a load that fluctuates continually from zero to a value of two or three times that which the motor will stand continuously. It is easy to overload such a motor, since it is expected to withstand large overloads for short periods and is designed with such service in view. Overheating takes place only when such overloading is continued for an undue length of time.

The solution which I wish to suggest is the use of an ammeter which does not respond instantly to the passage of current, but is delayed in its indication by the action of a law exactly similar to that which delays the heating of the motor. The motor does not heat up instantly because there is a considerable mass of material therein to be heated. If we had an ammeter depending on temperature for its indications and having the same mass-ventilation ratio as the motor, the indication of such an ammeter would always indicate the temperature rise of the motor. This is exactly what is proposed. Briefly, the thermal ammeter consists of two similar masses of material, one of which is heated by the passage of the current under measurement. The device is so constructed as to indicate the difference in temperature between the two masses of material. By adjusting the amount of material in the masses, the time of response of the ammeter is fixed and so long as this time of response does not exceed that of the motor, the indications of the ammeter may be used as a safe index of the temperature rise of the motor.

Figure 3 shows the graphic record about eight hours long of an ammeter of this type when carrying the load

shown in Figure 1. In this case the ammeter had a time of response of 30 minutes; that is, with the pen starting at zero, a steady load applied for 30 minutes would bring the pen 90 per cent of the way to its final position. Since the motor has a longer time of response to heating than this, the temperature rise of the motor could at no time have exceeded that due to the maximum current shown by this record, although for a few seconds at a time the actual current in the motor might rise to two or three times that indicated by the record shown in Figure 3. In other words, the record shown in Figure 3 is the heating effect of the current that flowed on the assumption that the motor had a time period of 30 minutes. Since the time period of the motor is really greater than 30 minutes, the temperature rise of the motor actually varies over a somewhat smaller range than shown in Figure 3, the maximum temperature rise attained being somewhat less than that corresponding to the highest value in Figure 3 and the minimum temperature rise being somewhat higher than the minimum of Figure 3.

Approximately five watts are required by one of these thermal ammeters at full load. Further, it is impossible to design an ammeter to carry the whole

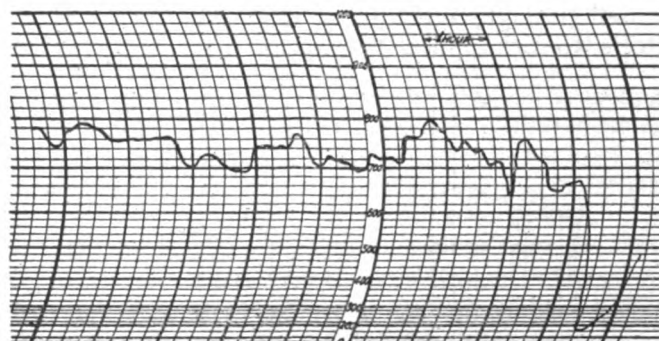


Fig. 3—Graphic record of thermal ammeter.

current of the large capacity motors that we have under consideration. The problem of conduction of heat along the large conductor required for these large currents make the design of a thermal ammeter for these large currents difficult, if not prohibitive. Twenty to 25 amperes through the meter has been found very satisfactory, but to get five watts into the meter with this amount of current requires a voltage across the meter of approximately .25 volts at full load. This is considerably more than can be obtained from the usual standard meter shunts. In the installations so far made this difficulty has been overcome by shunting the thermal meter across a section of bus bar as well as the meter shunts, the length of bus bar section being sufficient to give about .25 volts drop at full load.

In its graphic form, this device gives a continuous indication and record of the value of the average current through, and its heating effect on, the motor. It is only on relatively important installations that the expense of a graphic record is necessary. To protect less important installations, a similar thermal ammeter may be used to give an indication of danger by ringing an alarm or tripping the circuit breaker. The advantage in the use of this device is that overloading to any degree necessary is permitted and still due warning is given when dangerous heating is approached.

# Electric Furnaces in the Steel Industry

Report of the Electrical Furnace Committee of the A. I. S. E. E.  
Indicates the Development of Further Uses for Electric Furnace  
Steel — Well Standardized Auxiliary Equipment Available.

The rapidly increasing number of electric furnaces which are being installed by steel industries has attracted a great deal of attention. This growth has been occasioned by a demand for the special grade of steels that can be produced in the electric furnaces for rolling and forging, by the production of steel for castings, and by special uses such as melting alloys and smelting ferro-alloys. These requirements have called for the electric furnace so rapidly that today we find about 30 times as many furnaces installed in the United States as there were 10 years ago, when their use was first established.

Electric steels have taken a permanent place in those industries requiring high grade steel to produce the best results. The war period which we have just passed through, with its exacting demands for special steels to be applied to various purposes, has also

|                                                                                 |          |
|---------------------------------------------------------------------------------|----------|
| Rated capacity largest furnaces used for making ingots .....                    | 40 tons  |
| Rated capacity largest furnaces for making castings .....                       | 15 tons  |
| Largest plant installation for ingots (5 furnaces) total rated capacity .....   | 105 tons |
| Largest plant installation for castings (2 furnaces) total rated capacity ..... | 30 tons  |

The type of furnace used in at least 99 per cent of the cases is some form of arc furnace. The induction type of furnace is not being taken up with very great favor, nor is it being developed to any great extent. Furnaces of three tons capacity or larger are generally arranged for two or three phase current, and are to be preferred, from both power station and consumer's standpoint, on account of the better balancing effect on the phases. A number of small size single phase furnaces are also giving satisfactory service.

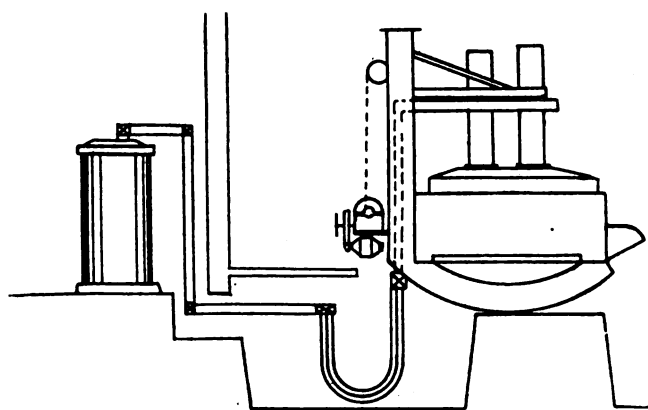


Fig. 1—Arrangement of bus bar and cable, 1,500 kw input.

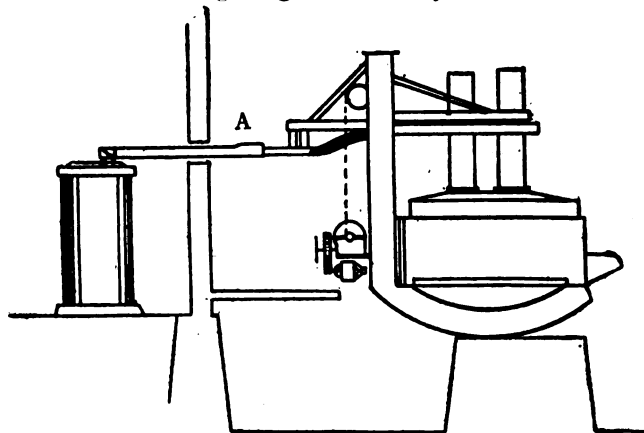


Fig. 2—Same furnace rebuilt having 2,500 kw input.

served to promote a larger production from electric furnaces, in order to obtain the most reliable material.

A study of available data reveals the following interesting facts regarding furnaces now installed or contracted for:

|                                                                |            |
|----------------------------------------------------------------|------------|
| Estimated total number of furnaces in world ....               | 815        |
| Estimated total number of furnaces in U. S. ....               | 290        |
| Estimated total number of furnaces in Canada ...               | 45         |
| Rated capacity of all furnaces in U. S. and Canada             | 1,130 tons |
| Average rated capacity of furnaces in U. S. and Canada .....   | 3.4 tons   |
| Number of furnaces U. S. and Canada making ingots .....        | 104        |
| Rated capacity furnaces U. S. and Canada making ingots .....   | 735 tons   |
| Average size furnaces U. S. and Canada making ingots .....     | 7.3 tons   |
| Number furnaces U. S. and Canada making castings .....         | 231        |
| Rated capacity furnaces U. S. and Canada making castings ..... | 395 tons   |
| Average size furnaces U. S. and Canada making castings .....   | 1.7        |
| Number plants U. S. and Canada making ingots                   | 60         |
| Number plants U. S. and Canada making castings                 | 126        |

Report read at St. Louis meeting of the Association of Iron and Steel Electrical Engineers.

Electric steel production may be roughly classed under two headings. That required for ingots, and that which is used directly in the pouring of castings.

In the case of ingot steel, two general plant arrangements are used; the one where steel is melted and refined in the electric furnace, and the other where molten steel, previously prepared in an open hearth, or other type furnace, is poured into the electric, and there put through a refining process. The latter plan results in a much greater output per electric unit, and also reduced costs, without any loss in the quality of the product.

In the production of steel castings, practically all plants are melting directly in the electric. This method seems to give very satisfactory plant operating conditions in the foundry business. A few foundries are equipped to charge their electric furnaces with molten metal, thus securing an increased output together with reduced costs as mentioned above.

Furnaces are giving satisfactory service on both 25 and 60 cycle circuits. The use of 25 cycle current, of course permits of a greater power input to a given

furnace than 60 cycle current would, owing to lesser magnetic losses and decreased heating and inductive effects in the circuits. A considerably better power factor condition is obtained with 25 cycle current than with 60 cycle, other conditions remaining the same. These points, it will be appreciated, apply with increased force as the amount of power input, and consequently the current grows larger.

The largest furnace in use on 60 cycle current is rated at 15 tons capacity. The power input to a large furnace, operating on 60 cycles, may be limited by the arrangement of electrical conductors between the transformers and the furnace electrodes.

As an example of this there can be cited the case of a 15-ton furnace which was equipped with a 3,000 K.V.A transformer capacity, and had a bus bar and cable arrangement as shown in (Fig. 1). With this layout it was found that 1,500 kw was about the maximum possible input to the furnace because above that amount the heating in cables and parts of the furnace gave trouble. In addition to this the power factor fell to a very low point.

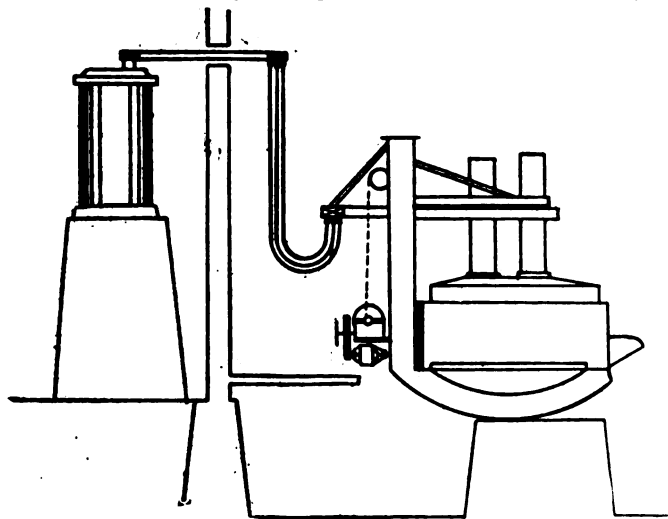


Fig. 3.

This same 15 ton furnace was rebuilt and arranged as shown in (Fig. 2). It was then found possible to secure an input of 2,500 kw into the furnace with a satisfactory power factor.

Experience has shown that a furnace taking a molten metal charge of about 30 tons requires from 2,000 to 2,500 kilowatts to handle the heat satisfactorily. It is therefore apparent that furnaces taking a 30 ton charge of hot, molten metal can be operated on 60 cycle circuits.

Furnace capacity is limited somewhat by the amount of power per electrode which can be handled, and 3,000 kva seems to be about the total capacity that should be handled on a three electrode furnace. It is for this reason that furnaces of 30 ton capacity are considered as large as it is advisable to construct at the present time. This size furnace, operating entirely on molten charges, should produce from 4,000 to 5,000 tons of steel per month using between 2,000 to 2,500 kw input. It will readily be seen that this amount of steel from one furnace will meet most plant requirements which can be foreseen at the present

time, and it is possible that the necessity for a larger furnace may not arise. If such should be the case, however, a unit could, no doubt, be constructed using six electrodes with a total capacity of from 50 to 60 tons per heat.

For installations requiring cold melting, furnaces of from 1 to 10 tons have been adopted. Sizes up to five or six tons consuming up to 1,000 kw can be equipped and operated satisfactorily using the electrical arrangement shown in Fig. 1. This scheme was used on the earliest furnaces and has proved to be a very good shop arrangement.

The relation of furnace and transformer and position of circuits shown in Fig. 3 has been used in some cases and proves to be satisfactory if substantially built. It is varied somewhat by sending the busses and cables down over the top of the mast. This scheme was considered ideal a few years ago.

The most recent installations of larger furnaces have used other methods of arrangement such as side-tilting where the furnace tilts in a plane parallel to the transformers. This results in a short cable link, and would appear to be practically the same as shown in Fig. 2 with the exception that the furnace would rotate through 90 degrees, the mast remaining as it is shown.

Fig. 2 illustrates a plan in which a disconnecting switch is made use of. The switch is indicated at A. By this device the shortest possible run is secured for the circuit between the transformers and electrodes. Although at first thought it might seem that trouble with such a device would be inevitable, a disconnecting switch of this type was developed and placed in use about a year ago, and up to the present it has been reported as having given no trouble whatever.

Note might be taken of the fact that the plan of Fig. 2 could be varied in such a manner as to have the operating motors installed at the top of the mast above the flexible cables, rather than at the bottom, thus making it possible, by installing a door in the back of the furnace, to pour off slag by a slight back-tilting of the furnace.

The auxiliary equipment used with electric furnaces has been very well standardized. Most furnaces are motor operated throughout excepting the smaller sizes which may be operated by hand. The furnaces using automatic control of electrodes may select any one of two or three standard makes of control which have proved satisfactory under severe service.

The growth and development of the electric furnace industry during the past 10 years judged by the practice in the United States has resulted in a well standardized equipment being available at the present time. Furnaces and their equipment can be purchased to meet any plant requirements.

The development of further uses for electric furnace steel is looked for in the near future. Further increase in the use of electric furnaces depends only upon a demand for the steels and is not limited by lack of furnace equipment. If the demand arises for the high quality of steel which can be produced by the electric furnace in preference to the open hearth steels, plants can be equipped to meet the demand.



# Practical Notes on Physical Tests of Steel

Discussion of Hardness Test — Sclerometric Methods, Brinell Tests, Shore Scleroscope. Fremont, Charpy and Izod Dynamic Tests. Practical Notes for Conducting Tests to Secure Accurate Results.

By AUSTIN B. WILSON.

## PART II.

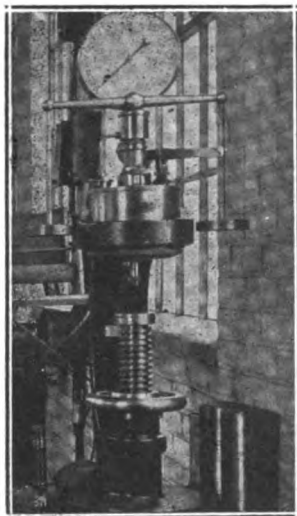


Fig. 1—Brinell hardness testing machine.

Next in importance to the tensile test and by far the most widely known of the remaining tests is the hardness test. Hardness, although one of the most important physical properties, is well-nigh impossible to define and it is not possible to express the results obtained by different methods of testing in the same units. It is, however, worthy of note that with a few exceptions the order of hardness obtained by the several methods are much the same.

Sclerometric methods measure the resistance of materials to cutting or scratching, i.e., hardness in a mineralogical sense. This is done either by comparing with the hardness of an arbitrary set of standardized minerals or by the measurement of the width of the scratch caused by drawing a sharp point under constant load over the surface of the specimen. Although valuable in their own sphere neither is readily applicable to every day metallurgical work.

The most important hardness test in technical practice consists in testing the resistance of the metal to the "local displacement of portions of itself." This is known as the Brinell test and is made by pressing a hardened steel ball, under known load, upon the surface of the metal to be tested and then measuring the circular indentation which remains. This test is easily and rapidly made and gives very concordant results. The Brinell hardness number has been found in a series of similar alloys to correspond proportionally with the maximum strength obtained by tensile testing. This is especially so in the case of plain carbon steels. As a criterion of the power to resist abrasion it is not so reliable. In the author's laboratory the Brinell test is preferred to all others for determining hardness when conditions allow of its application.

All that is required for the ball test which is simple indeed, is a good, hardened steel ball, some means of holding the ball and some means of applying the ball to the specimen under known load. Many different types of machines have been devised for this purpose, some operated by hydraulic pressure, some by a weighted lever, and some using merely dead weight. The one in the author's laboratory is actuated

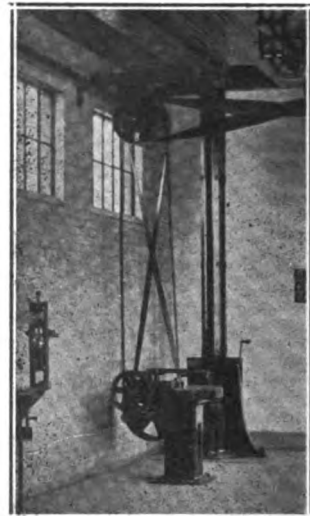


Fig. 2—Bending machine in foreground.

by hydraulic pressure. It is of a very satisfactory and widely used type of Swedish make, by the Aktiebolaget Alpha.

In Fig. 1 is shown the machine in use in the author's laboratory. The small hydraulic ram shown acts downwardly and carries the steel ball. Just below the ram is the table upon which the object to be tested rests. This table is made with a ball and socket joint and may be tilted at any angle. In this way no matter how irregular the shape of the specimen, it is always possible to present a flat surface for the test to be made upon. By means of the large wheel it is possible to raise and lower the table as desired. The small lever operates a small hand pump which generates the pressure, which may be read on the pressure gauge directly in kilograms. As gauges cannot be relied upon to remain accurate permanently a deadweight control is provided. By changing the weights which are carried by this control the maximum pressure obtainable may be varied from 500 to 3,000 kilograms. The cross-bar shown is the part of the control which carries the weights. Wrong readings are thus completely eliminated. Readings from the hydraulic control should always be given preference over those of the gauge. All moving parts of the hydraulic mechanism are made to operate without friction. The small microscope standing beside the machine is equipped with a rule graduated to one-tenth of a millimeter by means of which the indentation may be measured. The small valve just above the name plate closes the cylinder and allows the pressure to be applied. There is practically no part of this machine to get out of order in ordinary use.

An inexperienced man can after a few minutes instruction operate this machine and secure reliable results. A surface of the test-piece is filed flat and then polished with either a fine file or emery cloth. It is then adjusted on the press table. The table is moved upwards until a snug fit is made against the steel ball. The cylinder is then closed by means of the valve and the pressure is applied by working the pump handle gently up and down. When the control lifts the pumping is stopped. The gauge should now



give the desired pressure. The pressure is maintained for 30 seconds with a 500 kilogram load. It is then released by opening the valve. The table is lowered and the specimen removed. Now the indentation is measured with the microscope and the hardness number obtained from the chart furnished.

A few standards have been set in order to make all tests made by this method strictly comparable. To accomplish this it is advisable to use the same size ball and load. A ball 10 mm in diameter has been selected and a load of 3,000 kg for iron and steel. For non-ferrous metals a load of 500 kg is preferred. This method has been successfully employed for testing finished articles without damaging them, for testing results obtained by heat treatment, for checking chemical analysis, etc., etc. It is obvious that the utmost importance must be attached to any method which can give a numerical value for hardness of metals without elaborate preparation of the test-piece. Especially is this so when it is recalled with how many other of the physical properties hardness has been correlated.

In a few instances the metal to be tested may be so hard that the Brinell ball is flattened, i.e., the metal is harder than the ball. Therefore, some other method of testing must be employed. In this laboratory should this happen the test would be made by means of a small instrument called Shore's scleroscope. This test is based upon the rebound of a hard body from the piece being tested. The specimen having been polished is placed upon the anvil and the instrument is leveled up by means of the screws provided for that purpose. The tube through which the hammer falls has a ground lower edge which fits the specimen closely. A small steel cylinder fitted with a diamond point on the lower edge is raised in the tube by suction. It is then released and allowed to fall a distance of exactly 25 cm on to the test-piece. By means of a reading glass, which is attached, the height of the rebound is measured on a graduated scale on the tube and the reading gives the scleroscope hardness number direct.

This form of hardness is not the same as that measured by the Brinell method, but nevertheless the results obtained are in most cases in approximate agreement. There has been and still is much debate as to the accuracy of the scleroscope, but it has been found in this laboratory possible to obtain very reliable and concordant results by exercising a little care and judgment in its use. For determining surface hardness as in case-hardened articles it is particularly valuable.

The purely dynamic tests will next be considered. These are the direct impact tests in which the test-piece is broken by a single blow. Of these tests the methods developed by Fremont, Charpy and Izod are the most familiar. In the Izod test the bar is held in a fixed position in a vice attached to the base of the machine. A heavy pendulum with a suitable striking edge is allowed to drop from a known height and the energy used in breaking the bar is shown by a scale provided for that purpose. The Charpy method is quite similar to this, the only difference being that the

bar is supported at either end instead of being clamped in a vice at one end. Both of the above tests use a notched bar, the use of which will be discussed later. The results are given in foot-pounds.

The Fremont test is the one with which the author is best acquainted. Very satisfactory and concordant results have been obtained by this method of which a short description will be given. Fig. 2, although too small to convey details, will at least give the reader some idea of the appearance of the apparatus used in making this test. The small machine in the foreground is for making bending tests which will not be taken up in this article as bending tests are at best merely approximations and can be made satisfactorily in innumerable ways. In the corner is shown the Fremont machine. It was found necessary to cut a hole

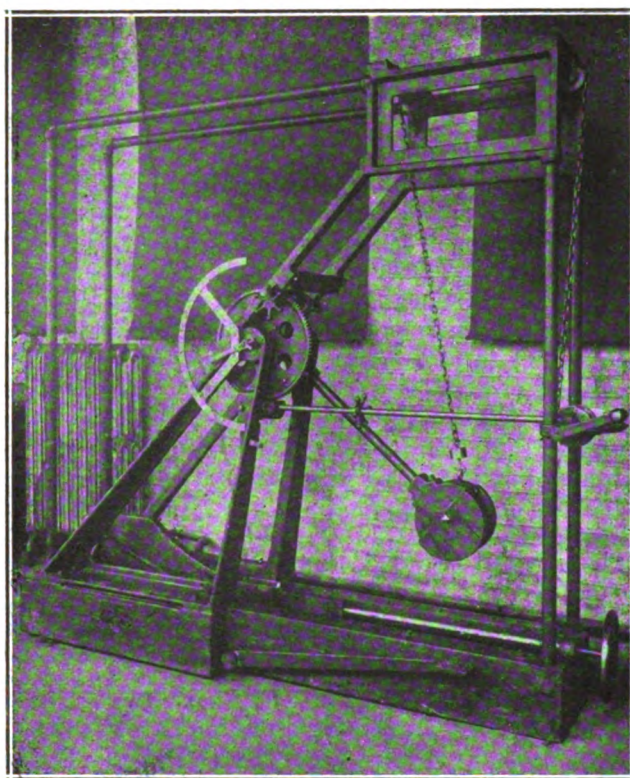


Fig. 3—McAdam's impact shear machine.

through the roof and extend a metal covering up several feet in order to accommodate the shaft which guides the falling weight. The maximum height from which this may be dropped is four meters. The weight used is 10 kilograms, thus the full capacity of the machine is 40 kilogram meters. The weight is raised by a small hand winch and can be tripped at any desired height. On the bottom of the weight is a pointed tup about  $2\frac{1}{2}$  inches long. The test-piece is placed with the notched edge down across a hole about 20 millimeters square through which the tup plunges. This hole is in the base of the machine and above this is another hole through the cross-bar which rests at either end upon heavy springs. The tup strikes the test-bar, breaks it and plunging through the hole, allows the sides of the falling weight to strike the cross-head. The cross-head is forced down-



wards and strikes a plunger which records the energy remaining after the test-piece is broken. This energy expressed in kilogram meters is subtracted from the total energy developed by the weight in falling and the remainder is the force absorbed in causing rupture in the piece. The test-piece used is 30 mm long and 8 mm by 10 mm in cross-section. The notch is 1 mm deep and is cut in the 10 mm side. Care must be taken to place the bar exactly over the center of the hole to insure the tup striking the notched part fairly.

A more recent development of the single blow test is the McAdam impact-shear test in which an unnotched bar is used. The machine is shown in Fig. 3. The pendulum is raised as can be readily seen by means of the chain and winch. The height from which the weight falls is regulated by adjusting the star-shaped wheel on the long horizontal rod. Releasing the pendulum is accomplished with the other star-wheel shown at the upper part of the large toothed wheel. The pendulum swings downward and by means of a knife-edge fitted in its center the test-piece is sheared off. In the picture the end of the test-piece is represented as a small white bar. It is held in the vice which is tightened by the large wheel near the floor. As the pendulum swings, the pointer on the indicator is moved forward by a short lever connected to the axle upon which the pendulum is hung. The resistance of the bar to shearing, i. e., the energy absorbed, is calculated in the same manner as in the other impact tests. The pendulum is stopped by pressing down the foot lever which tightens the chain near the machine's base so that the pendulum rubs against it. The machine is well built and built in such a way that friction is minimized. The test-piece used is  $\frac{1}{4}$  inch by  $\frac{1}{2}$  inch and the larger side is presented for the blow.

In connection with the single blow tests there are several points worthy of mention. There is no means of calculating the stress per square unit of area, so it therefore is necessary in order to secure comparable results that the same size and shape of test-piece be used. It is also advisable to employ the same weight and height of drop although theoretically this is not required. Tests made by different methods should not be compared, such as tests on notched and unnotched bars. These two classes of tests are used for testing very different properties of metals and each is of particular value in its own field. Both of these classes have shown remarkable variations in the physical properties of materials which have failed in service, variations which the static tests have failed to reveal. The advantages claimed for the impact-shear test are the application of a single kind of stress, the use of the unnotched bar which removes the uncertainty due to the effect of the notch, and that the specimen may be moved along and sheared several times by which means average results may be secured. The particular instances in which the notched bar tests are of greatest value are in testing materials which are to be subjected to impact or shearing stresses in a notched condition, i. e., when notches are present in the finished material due either to error in design or faulty workmanship. In these cases tests on unnotched bars are of no real value as the localizing of stresses caused by the notched effect are not duplicated. It is the practice in the writer's laboratory to use the drop test on the more brittle materials and the impact-shear test on the more ductile. With sufficient care in conducting all tests in a similar manner and judgment in interpreting the results these tests may very well be relied upon to furnish valuable data.

## Modern Steel Metallurgical Calculations

### Acid Open-Hearth Process With Fifty Per Cent Iron and Fifty Per Cent Scrap—Basic Open Hearth Process With Fifty Per Cent Common Forge Iron and Fifty Per Cent Steel Scrap.

By CHARLES H. F. BAGLEY.

PART III.

#### 1. Acid Open Hearth Process, With 50 Per Cent Hematite Iron and 50 Per Cent Scrap.

The average analysis per 100 tons charged will be approximately:

|                                               |                           |                   |
|-----------------------------------------------|---------------------------|-------------------|
| Carbon from 50 tons of hematite at.....       | 3.80 per cent = 1.90 tons | } = 2.00 per cent |
| Carbon from 50 tons of scrap at (say).....    | 0.20 per cent = 0.10 tons |                   |
| Silicon from 50 tons of hematite at.....      | 2.50 per cent = 1.25 tons | } = 1.30 per cent |
| Silicon from 50 tons of scrap at (say).....   | 0.10 per cent = 0.05 tons |                   |
| Manganese from 50 tons of hematite at.....    | 1.00 per cent = 0.50 tons | } = 0.80 per cent |
| Manganese from 50 tons of scrap at (say)..... | 0.60 per cent = 0.30 tons |                   |

Oxidation Table—If the steel before tapping is to contain 0.20 per cent carbon, 0.10 silicon, and no manganese, there will be oxidized per 100 tons charged:

|                 |                                                                                 |
|-----------------|---------------------------------------------------------------------------------|
| Carbon .....    | 1.80 tons requiring oxygen = 2.40 tons and producing 4.20 tons CO gas           |
| Silicon .....   | 1.20 tons requiring oxygen = 1.37 tons and producing 2.57 tons SiO <sub>2</sub> |
| Manganese ..... | 0.80 tons requiring oxygen = 0.23 tons and producing 1.03 tons MnO              |
| Totals .....    | 3.80 tons requiring oxygen = 4.00 tons and producing 3.60 tons solids           |

Paper read before British Iron and Steel Institute.



**Oxides**—Against this four tons of oxygen required, there is the 1.90 tons supplied by the melting down of the charge, leaving only 2.10 tons to be supplied by additions—equivalent to  $2.10 \div 0.30 = 7.00$  tons of  $\text{Fe}_2\text{O}_3$ . If supplied as ore containing 65 per cent Fe and 3.0 per cent  $\text{SiO}_2$ , the quantity required will be approximately 7.52 tons of ore, introducing 4.90 tons Fe and 0.22 tons of  $\text{SiO}_2$ .

Slag—The total  $\text{SiO}_2$  present is now:

|                                                | Tons.       |
|------------------------------------------------|-------------|
| SiO <sub>2</sub> Oxidized from the charge..... | 2.57        |
| Sand allowance at ¼ cwt.....                   | 0.62        |
| Brought in by ore.....                         | 0.22        |
| <b>Total .....</b>                             | <b>3.41</b> |

Table 1.—Acid Open Hearth Process. Hematite Iron (M  
Nos.) Scrap Results Per 100 Tons Charged.

| Proportion of scrap used                                                                                                              | 33 per Cent.                                        | 50 per Cent.                                        | 67 per Cent.                                        |
|---------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|
| Metalloids oxidised . . . . .                                                                                                         | 4.87                                                | 3.80.                                               | 2.73                                                |
| Oxygen required . . . . .                                                                                                             | 5.28                                                | 4.00                                                | 2.73                                                |
| Less Fe <sub>2</sub> O <sub>3</sub> made, oxygen equivalent . . . . .                                                                 | 1.90                                                | 1.90                                                | 1.90                                                |
| Oxygen required from oxides . . . . .                                                                                                 | 3.38                                                | 2.10                                                | 0.93                                                |
| Equivalent Fe <sub>2</sub> O <sub>3</sub> (70 per cent. Fe) . . . . .                                                                 | 11.30                                               | 7.00                                                | 2.77                                                |
| Equivalent ore (at 65 per cent. Fe) . . . . .                                                                                         | 12.15                                               | 7.52                                                | 2.98                                                |
| Fe introduced . . . . .                                                                                                               | 7.91                                                | 4.90                                                | 1.94                                                |
| SiO <sub>2</sub> introduced (at 3 per cent.) . . . . .                                                                                | 0.36                                                | 0.22                                                | 0.09                                                |
| <i>Acids:</i> SiO <sub>2</sub> { from metal<br>" sand allowance<br>" ore . . . . .                                                    | 3.43<br>0.62<br>0.36                                | 2.57<br>0.62<br>0.22                                | 1.72<br>0.62<br>0.09                                |
| Total acids . . . . .                                                                                                                 | 4.41                                                | 3.41                                                | 2.43                                                |
| Slag make (for 50 per cent. SiO <sub>2</sub> ) . . . . .                                                                              | 8.82                                                | 6.82                                                | 4.96                                                |
| <i>Slag Analysis:</i> { SiO <sub>2</sub> . . . . .<br>MnO . . . . .<br>Al <sub>2</sub> O <sub>3</sub> , etc. . . . .<br>FeO . . . . . | 4.41 = 50.0<br>1.12 = 12.7<br>at 2.0<br>3.12 = 35.3 | 3.41 = 50.0<br>1.03 = 15.1<br>at 2.0<br>2.25 = 32.9 | 2.43 = 50.0<br>0.94 = 19.3<br>at 2.0<br>1.39 = 28.7 |
| Totals . . . . .                                                                                                                      | 8.82 = 100.0                                        | 6.82 = 100.0                                        | 4.96 = 100.0                                        |
| <i>Metallic Balance Sheet:</i><br><i>Dr.</i> Metallic charge . . . . .<br>Fe from ore . . . . .<br>Ferro alloys . . . . .             | 100.00<br>7.91<br>0.70                              | 100.00<br>4.90<br>0.70                              | 100.00<br>1.94<br>0.70                              |
| Totals . . . . .                                                                                                                      | 108.61                                              | 105.60                                              | 102.64                                              |
| <i>Cr. Sand allowance</i> . . . . .                                                                                                   | 0.62                                                | 0.62                                                | 0.62                                                |
| Metalloids oxidised . . . . .                                                                                                         | 4.87                                                | 3.80                                                | 2.73                                                |
| Fe (no oxide) in slag . . . . .                                                                                                       | 2.43                                                | 1.75                                                | 1.08                                                |
| Mechanical losses } (ray)<br>Volatilised          }                                                                                   | 2.00                                                | 2.00                                                | 2.00                                                |
| Yield—ingots and scrap . . . . .                                                                                                      | 98.69                                               | 97.43                                               | 96.20                                               |
| Totals . . . . .                                                                                                                      | 108.61                                              | 105.60                                              | 102.64                                              |

If the slag is to contain 50 per cent  $\text{SiO}_2$ , the total slag made will be  $3.41 \div 0.50 = 6.82$  tons; made up as under:

|                                            |           |    |       |                  |
|--------------------------------------------|-----------|----|-------|------------------|
| SiO <sub>2</sub> .....                     | 3.41 tons | =  | 50.0  |                  |
| MnO .....                                  | 1.03 tons | =  | 15.1  |                  |
| Al <sub>2</sub> O <sub>3</sub> , etc. .... |           | at | 2.0   |                  |
| FeO .....                                  | 2.25 tons | =  | 32.9  | (Fe = 1.75 tons) |
| Totals .....                               | 6.82 tons | =  | 100.0 |                  |

The metallic balance sheet will be approximately:

|                        |        |                          |            |
|------------------------|--------|--------------------------|------------|
| Dr. Metallic charge... | 100.00 | Cr. Sand allowance ..... | 0.62       |
| Fe from ore.....       | 4.90   | Metalloids oxidized..... | 3.80       |
| Ferro alloys (say)     | 0.70   | Fe (as oxide) in slag... | 1.75       |
|                        |        | Mechanical losses }      |            |
|                        |        | Volatilized }            | (say) 2.00 |
|                        |        | Yield—ingots and scrap.  | 97.43      |
| Total .....            | 105.60 | Total .....              | 105.60     |

Note—The effect of adding lime or limestone—a more powerful base than FeO, and therefore permitting a higher percentage of SiO<sub>2</sub> in the slag—is important; and is well illustrated by the calculation of the slag as under. For a slag to contain 60 per cent SiO<sub>2</sub> and 10 per cent CaO, the total make of slag will be about  $3.41 \div 0.60 = 5.69$  tons; made up as under:

|                                       |                |    |       |                               |
|---------------------------------------|----------------|----|-------|-------------------------------|
| SiO <sub>2</sub>                      | .....3.41 tons | =  | 60.0  |                               |
| MnO                                   | .....1.03 tons | =  | 18.1  |                               |
| CaO                                   | .....0.57 tons | at | 10.0  | (= 0.60% on the total charge) |
| Al <sub>2</sub> O <sub>3</sub> , etc. |                | at | 2.0   |                               |
| FeO                                   | .....0.56 tons | =  | 9.9   | (Fe = 0.44 tons)              |
| Totals                                | ...5.69 tons   | =  | 100.0 |                               |

This indicates a saving in the loss of Fe as oxide in the slag of over 1¼ per cent (a gain of over 1¼ per cent in the yield), together with a 20 per cent

Table 2—Basic Open Hearth Process—50 Per Cent Pig Iron,  
50 Per Cent Scrap. Results per 100 Tons Charged.

| Pig Iron Used.                                                                                                                                                                     | Hæm. (Spec.)                                                                        | Com. Forge.                                                                          | Com. Basic.                                                                         | "Thomas."                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Metalloids oxidised (tons) . . .                                                                                                                                                   | 2-68                                                                                | 3-85                                                                                 | 3-47                                                                                | 4-22                                                                                 |
| Oxygen required . . .                                                                                                                                                              | 2-84                                                                                | 4-40                                                                                 | 3-66                                                                                | 4-17                                                                                 |
| Less Fe <sub>2</sub> O <sub>3</sub> , equivalent oxygen . .                                                                                                                        | 1-90                                                                                | 1-90                                                                                 | 1-90                                                                                | 1-90                                                                                 |
| Oxygen required (as Fe <sub>2</sub> O <sub>3</sub> ) . .                                                                                                                           | 0-94                                                                                | 2-50                                                                                 | 1-76                                                                                | 2-27                                                                                 |
| Equivalent Fe <sub>2</sub> O <sub>3</sub> . . .                                                                                                                                    | 3-12                                                                                | 8-33                                                                                 | 5-87                                                                                | 7-55                                                                                 |
| Equivalent ore (at 65 per cent. Fe) . . .                                                                                                                                          | 3-36                                                                                | 9-00                                                                                 | 6-32                                                                                | 8-14                                                                                 |
| Fe introduced . . .                                                                                                                                                                | 2-18                                                                                | 5-84                                                                                 | 4-11                                                                                | 5-28                                                                                 |
| SiO <sub>2</sub> introduced (at 3 per cent. of ore) . . .                                                                                                                          | 0-10                                                                                | 0-27                                                                                 | 0-19                                                                                | 0-24                                                                                 |
| <i>Acids:</i><br>SiO <sub>2</sub> { from charge . . .<br>" sand allowance . . .<br>" from ore . . .<br>" lime . . .<br>P <sub>2</sub> O <sub>5</sub> " charge . . .                | 1-18<br>0-62<br>0-10<br>0-08<br>0-07                                                | 2-03<br>0-62<br>0-27<br>0-18<br>1-72                                                 | 1-18<br>0-62<br>0-19<br>0-14<br>1-42                                                | 0-64<br>0-62<br>0-24<br>0-16<br>2-67                                                 |
| Total acids . . .                                                                                                                                                                  | 2-05                                                                                | 4-83                                                                                 | 3-55                                                                                | 4-23                                                                                 |
| <i>Slag make (at 28 per cent. acids)</i><br><i>Lime required (for 48 per cent. CaO)</i>                                                                                            | 7-83<br>3-66                                                                        | 17-2<br>8-6                                                                          | 12-7<br>6-3                                                                         | 15-1<br>7-5                                                                          |
| <i>Slag Analysis:</i><br>SiO <sub>2</sub> . . .<br>P <sub>2</sub> O <sub>5</sub> . . .<br>MnO . . .<br>CaO . . .<br>MgO . . .<br>Al <sub>2</sub> O <sub>3</sub> . . .<br>FeO . . . | 1-98 = 27-0<br>0-07 = 1-0<br>0-77 = 10-5<br>at 48-0<br>" 5-0<br>" 1-0<br>0-55 = 7-5 | 3-10 = 18-0<br>1-72 = 10-0<br>0-65 = 3-8<br>at 48-0<br>" 5-0<br>" 1-0<br>2-44 = 14-2 | 2-13 = 16-8<br>1-42 = 11-2<br>1-03 = 8-1<br>at 48-0<br>" 5-0<br>" 1-0<br>1-26 = 9-9 | 1-66 = 11-0<br>2-67 = 17-0<br>1-68 = 11-1<br>at 48-0<br>" 5-0<br>" 1-0<br>1-11 = 6-9 |
| Totals . . .                                                                                                                                                                       | 7-33 = 100-00                                                                       | 17-2 = 100-00                                                                        | 12-7 = 100-00                                                                       | 15-1 = 100-0                                                                         |
| <i>Metallic Balance Sheet:</i><br><i>Dr.</i> Metallic charge . . .<br>Fe from ore . . .<br>Ferrous alloys (say) . . .                                                              | 100-00<br>2-18<br>0-70                                                              | 100-00<br>5-84<br>0-70                                                               | 100-00<br>4-11<br>0-70                                                              | 100-00<br>5-28<br>0-70                                                               |
| Total . . .                                                                                                                                                                        | 102-88                                                                              | 106-54                                                                               | 104-81                                                                              | 106-98                                                                               |
| <i>Or.</i> Sand allowance . . .<br>Metalloids oxidised . . .<br>Fe (as oxide) in slag . . .<br>Mechanical losses } (say)<br>Volatilised }<br>Yield—ingots and scrap . . .          | 0-62<br>2-68<br>0-43<br>3-00<br>96-15                                               | 0-62<br>3-85<br>1-90<br>3-00<br>97-17                                                | 0-62<br>3-47<br>0-98<br>3-00<br>96-74                                               | 0-62<br>4-22<br>0-88<br>3-00<br>97-28                                                |
| Total . . .                                                                                                                                                                        | 102-88                                                                              | 106-54                                                                               | 104-81                                                                              | 106-98                                                                               |

saving in the weight of slag made (and to be handled), which in itself should tend to increase the output of steel. It should be fed into the furnace when normally the first feed of ore would be given—thereby liberating the excess oxide in the slag—which method is found to give the best results in practice.

2. Basic Open Hearth Process With 50 Per Cent Common Forge Iron and 50 Per Cent Steel Scrap. The average analysis of the charge—100 tons—will be:

|                                                |                           |                   |
|------------------------------------------------|---------------------------|-------------------|
| Carbon from 50 tons of pig at.....             | 3.50 per cent = 1.75 tons | } = 1.85 per cent |
| Carbon from 50 tons of scrap at (say).....     | 0.20 per cent = 0.10 tons |                   |
| Silicon from 50 tons of pig at.....            | 1.80 per cent = 0.90 tons | } = 0.95 per cent |
| Silicon from 50 tons of scrap at (say).....    | 0.10 per cent = 0.05 tons |                   |
| Phosphorus from 50 tons of pig at.....         | 1.50 per cent = 0.75 tons | } = 0.78 per cent |
| Phosphorus from 50 tons of scrap at (say)..... | 0.06 per cent = 0.03 tons |                   |
| Manganese from 50 tons of pig at.....          | 0.60 per cent = 0.30 tons | } = 0.60 per cent |
| Manganese from 50 tons of scrap at (say).....  | 0.60 per cent = 0.30 tons |                   |

Oxidation Table—If the steel before tapping is to contain 0.20 per cent carbon, 0.03 phosphorus, 0.10 manganese, and no silicon, there will be oxidized per 100 tons charged:

|                  |                                                                                              |
|------------------|----------------------------------------------------------------------------------------------|
| Carbon .....     | 1.65 tons requiring oxygen = 2.20 tons and producing 3.85 tons CO gas                        |
| Silicon .....    | 0.95 tons requiring oxygen = 1.08 tons and producing 2.03 tons SiO <sub>2</sub>              |
| Phosphorus ..... | 0.75 tons requiring oxygen = 0.97 tons and producing 1.72 tons P <sub>2</sub> O <sub>5</sub> |
| Manganese .....  | 0.50 tons requiring oxygen = 0.15 tons and producing 0.65 tons MnO                           |
| Totals .....     | 3.85 tons requiring oxygen = 4.40 tons and producing 4.40 tons solids                        |

Oxides—Against this 4.40 tons of oxygen required there is some 1.90 tons supplied by the oxidation of the charge in melting, leaving only 2.50 tons to be supplied by ore additions—equivalent to  $2.50 \div 0.30$

Table 3—Basic Open Hearth (Martin) Process—25 Per Cent Pig Iron and 75 Per Cent Scrap. Results per 100 Tons Charged.

| Pig Iron Used.                                                | 1.                | 2.                                      | 3.           | 4.           | 5.           |
|---------------------------------------------------------------|-------------------|-----------------------------------------|--------------|--------------|--------------|
|                                                               | Hematite (M. No.) | Hematite (Spec.)                        | Com. Forge.  | Com. Basic.  | "Thomas."    |
| Metalloids oxidized (tons).                                   | 9.13              | 1.56                                    | 9.12         | 1.95         | 2.31         |
| Oxygen required                                               | 9.18              | 1.55                                    | 2.30         | 1.95         | 2.18         |
| Less Fe <sub>2</sub> O <sub>3</sub> equivalent oxy. gen.      | 1.90              | 1.90                                    | 1.90         | 1.90         | 1.90         |
| Net oxygen required                                           | 0.28              | nil (excess)                            | 0.40         | 0.05         | 0.28         |
| Equivalent Fe <sub>2</sub> O <sub>3</sub>                     | 0.93              | 0.35                                    | 1.33         | ...          | 0.93         |
| Equivalent ore at 65 per cent. Fe                             | 1.00              | unworkable                              | 1.44         | nil          | 1.00         |
| Fe introduced                                                 | 0.93              | without a large proportion of pig iron. | 0.94         | ..           | 0.93         |
| SiO <sub>2</sub> introduced (at 3 per cent SiO <sub>2</sub> ) | 0.03              |                                         | 0.04         | ..           | 0.03         |
| Acids:                                                        |                   |                                         |              |              |              |
| from charge                                                   | 1.50              |                                         | 1.12         | 0.68         | 0.43         |
| SiO <sub>2</sub> sand allowance                               | 0.31              |                                         | 0.31         | 0.31         | 0.31         |
| from ore                                                      | 0.03              |                                         | 0.04         | ...          | 0.03         |
| lime                                                          | 0.07              |                                         | 0.08         | 0.08         | 0.07         |
| P <sub>2</sub> O <sub>5</sub> charge                          | 0.07              |                                         | 0.02         | 0.76         | 1.28         |
| Total acids                                                   | 1.98              |                                         | 2.48         | 1.91         | 2.12         |
| Slag Make (at 28 per cent. acids)                             | 7.08              |                                         | 8.86         | 6.47         | 7.54         |
| Lime required (for 48 per cent. CaO)                          | 3.54              |                                         | 4.43         | 3.24         | 3.77         |
| Slag Analysis:                                                |                   |                                         |              |              |              |
| SiO <sub>2</sub>                                              | 1.91 = 27.0       |                                         | 1.56 = 17.6  | 1.05 = 16.3  | 0.64 = 11.0  |
| P <sub>2</sub> O <sub>5</sub>                                 | 0.07 = 1.0        |                                         | 0.92 = 10.4  | 0.76 = 11.7  | 1.28 = 17.0  |
| MnO                                                           | 0.64 = 9.0        |                                         | 0.52 = 5.9   | 0.71 = 11.0  | 1.03 = 13.6  |
| CaO                                                           | at 48.0           |                                         | at 48.0      | at 48.0      | at 48.0      |
| MgO                                                           | .. 5.0            |                                         | .. 5.0       | .. 5.0       | .. 5.0       |
| Al <sub>2</sub> O <sub>3</sub>                                | .. 1.0            |                                         | .. 1.0       | .. 1.0       | .. 1.0       |
| FeO                                                           | 0.64 = 9.0        |                                         | 1.07 = 12.1  | 0.46 = 7.0   | 0.33 = 4.4   |
| Totals                                                        | 7.08 = 100.0      |                                         | 8.86 = 100.0 | 6.47 = 100.0 | 7.54 = 100.0 |
| Metallic Balance Sheet:                                       |                   |                                         |              |              |              |
| Dr. Metallic charge                                           | 100.00            |                                         | 100.00       | 100.00       | 100.00       |
| Fe from ore                                                   | 0.93              |                                         | 0.94         | ...          | 0.93         |
| Ferro alloys (say)                                            | 0.70              |                                         | 0.70         | 0.70         | 0.70         |
| Total                                                         | 101.63            |                                         | 101.64       | 100.70       | 101.63       |
| Cr. Sand allowance                                            | 0.31              |                                         | 0.31         | 0.31         | 0.31         |
| Metalloids oxidized                                           | 2.12              |                                         | 2.12         | 1.95         | 2.31         |
| Fe (as oxide) in slag                                         | 0.50              |                                         | 0.83         | 0.36         | 0.27         |
| Mechanical losses                                             | 3.00              |                                         | 3.00         | 3.00         | 3.00         |
| Volatilized                                                   | .. say            |                                         | .. say       | .. say       | .. say       |
| Yield—ingots and scrap                                        | 95.20             |                                         | 95.28        | 95.08        | 95.44        |
| Total                                                         | 101.63            |                                         | 101.64       | 100.70       | 101.63       |

= 8.34 tons of Fe<sub>2</sub>O<sub>3</sub>. If supplied by ore containing 65 per cent Fe and 3.0 per cent SiO<sub>2</sub>, the quantity required will be 9.0 tons of ore, introducing 5.84 tons of Fe and 0.27 tons of SiO<sub>2</sub>. Where there is any

appreciable quantity of P<sub>2</sub>O<sub>5</sub> in the ore, or of SiO<sub>2</sub> and P<sub>2</sub>O<sub>5</sub> in the lime, it should be taken into account here. The lime required may be roughly estimated in advance. Slag, make, Lime, etc.—The acids present are: now are:

|                               |                                       |      |               |
|-------------------------------|---------------------------------------|------|---------------|
| SiO <sub>2</sub>              | Oxidized from the charge.....         | 2.03 | } = 3.10 tons |
|                               | Sand allowance at ¼ cwt.....          | 0.62 |               |
|                               | From ore, as above .....              | 0.27 |               |
|                               | From lime, at 2.0 per cent (say)..... | 0.18 |               |
| P <sub>2</sub> O <sub>5</sub> | Oxidized from the charge.....         | 1.72 |               |

Total ..... 4.82

If the slag is to contain 28 per cent acids, the total slag make will be  $4.82 \div 0.28 = 17.20$  tons, and the lime required to give 48.0 per cent CaO in the slag will be 8.60 tons.

The slag analysis will be approximately as under:

|                                |                                   |
|--------------------------------|-----------------------------------|
| SiO <sub>2</sub>               | 3.10 tons = 18.0                  |
| P <sub>2</sub> O <sub>5</sub>  | 1.72 tons = 10.0                  |
| MnO                            | 0.65 tons = 3.8                   |
| CaO                            | at 48.0                           |
| MgO                            | at 5.0                            |
| Al <sub>2</sub> O <sub>3</sub> | at 1.0                            |
| FeO                            | 2.44 tons = 14.2 (Fe = 1.90 tons) |

Totals ..... 17.20 tons = 100.0

The metallic balance sheet will be approximately:

|                          |        |                          |            |
|--------------------------|--------|--------------------------|------------|
| Dr. Metallic charge..... | 100.00 | Cr. Sand allowance ..... | 0.62       |
| Fe with oxides....       | 5.84   | Metalloids oxidized..... | 3.85       |
| Ferro alloys (say) 0.70  |        | Fe (as oxide) in slag..  | 1.90       |
|                          |        | Mechanical losses        | (say) 3.00 |
|                          |        | Volatilized              |            |
|                          |        | Yield—ingots and scrap   | 97.17      |

Total ..... 106.54 Total ..... 106.54

NOTE—The following calculations and discussion refer to the basic open hearth process as per the analyses indicated under item 3, next page.

Oxides—Against this 1.95 tons of oxygen required there is already 1.90 tons supplied by the oxidation of the charge in melting, so that no additions of ore will be required, nor will any Fe or SiO<sub>2</sub> be introduced from that source.

Slag, Make, Lime, etc.—The acids present are:

|                               |                               |      |               |
|-------------------------------|-------------------------------|------|---------------|
| SiO <sub>2</sub>              | Oxidized from the charge..... | 0.68 | } = 1.05 tons |
|                               | Sand allowance .....          | 0.31 |               |
|                               | From oxides .....             | 0.06 |               |
|                               | From lime (say).....          | 0.06 |               |
| P <sub>2</sub> O <sub>5</sub> | Oxidized from the charge..... | 0.76 |               |

Total ..... 1.81

If the slag is to contain 28.0 per cent acids, the total slag make will be  $1.81 \div 0.28 = 6.47$  tons, and the lime consumption to give 48 per cent CaO in the

slag will be approximately 3.24 tons.

The composition of the slag will be approximately.

|                                |             |                      |
|--------------------------------|-------------|----------------------|
| SiO <sub>2</sub>               | 1.05 tons = | 16.3                 |
| P <sub>2</sub> O <sub>5</sub>  | 0.76 tons = | 11.7                 |
| MnO                            | 0.71 tons = | 11.0                 |
| CaO                            | at          | 48.0                 |
| MgO                            | at          | 5.0                  |
| Al <sub>2</sub> O <sub>3</sub> | at          | 1.0                  |
| FeO                            | 0.46 tons = | 7.0 (Fe = 0.36 tons) |
| Totals                         | 6.47 tons = | 100.0                |

The metallic balance sheet will be approximately:

|                             |                         |            |
|-----------------------------|-------------------------|------------|
| Dr. Metallic charge..100.00 | Cr. Sand allowance..... | 0.31       |
| Fe from oxides....          | Metalloids oxidized.... | 1.95       |
| Ferro alloys (say). 0.70    | Fe (as oxide) in slag.. | 0.36       |
|                             | Mechanical losses }     |            |
|                             | Volatilized }           | (say) 3.00 |
|                             | Yield—ingots and scrap  | 95.08      |
| <hr/>                       |                         | <hr/>      |
| Total .....100.70           | Total .....100.70       |            |

3. Basic Open Hearth (Martin) Process, With 25 Per Cent Common Basic Pig and 75 Per Cent Scrap.

The average analysis of the charge—100 tons—will be:

|                                                |                           |                   |
|------------------------------------------------|---------------------------|-------------------|
| Carbon from 25 tons of pig at.....             | 3.20 per cent = 0.80 tons | } = 0.95 per cent |
| Carbon from 75 tons of scrap at (say).....     | 0.20 per cent = 0.15 tons |                   |
| Silicon from 25 tons of pig at.....            | 1.00 per cent = 0.25 tons | } = 0.32 per cent |
| Carbon from 75 tons of scrap at (say).....     | 0.10 per cent = 0.07 tons |                   |
| Phosphorus from 25 tons of pig at.....         | 1.25 per cent = 0.31 tons | } = 0.35 per cent |
| Phosphorus from 75 tons of scrap at (say)..... | 0.06 per cent = 0.04 tons |                   |
| Manganese from 25 tons of pig at.....          | 1.20 per cent = 0.30 tons | } = 0.75 per cent |
| Manganese from 75 tons of scrap at (say).....  | 0.60 per cent = 0.45 tons |                   |

Oxidation Table—If the steel before tapping is to contain 0.20 per cent carbon, 0.03 phosphorus, 0.20 manganese, and no silicon, there will be oxidized per 100 tons of charge:

|            |                                                                                              |
|------------|----------------------------------------------------------------------------------------------|
| Carbon     | 0.75 tons requiring oxygen = 1.00 tons and producing 1.75 tons CO gas                        |
| Silicon    | 0.32 tons requiring oxygen = 0.36 tons and producing 0.68 tons SiO <sub>2</sub>              |
| Phosphorus | 0.33 tons requiring oxygen = 0.43 tons and producing 0.76 tons P <sub>2</sub> O <sub>5</sub> |
| Manganese  | 0.55 tons requiring oxygen = 0.16 tons and producing 0.71 tons MnO                           |
| Totals     | 1.95 tons requiring oxygen      1.95 tons and producing 2.15 tons solids                     |

# Motors for Rolling Mill Table Drives

Consideration of A.C. vs. D.C. Motors for Table Drives—Curves and Data from Existing Installations—Local Conditions Must Govern Choice of Type of Motor.

By W. S. HALL.

The adoption of the alternating current motor for rolling mill table drives is a question to which all of us will probably give more consideration in the future than we have in the past, on account of the increasing demand for more efficient operation, so that the cost of producing a ton of steel product will be reduced to the minimum.

In applying the expression "efficient operation" to an electric drive, it should be taken in the proper sense, meaning that it includes something more than the operating economy and first cost of one type of motor compared with these factors as applied to the other type of motor. This paper will consider the various items which go to make up the factors of economical operation as a whole. Good engineering practice demands that each application be considered primarily on its own merits and secondarily in its relation to the general scheme as a whole. This in many cases will result in compromises which in themselves are somewhat unsatisfactory, but in their relation to the whole may be preeminently satisfactory.

In general the alternating current motor can be made to do anything that the direct current will do. Even for rolling mill drives which require rapid acceleration and rapid reversals, the question becomes prim-

Paper read before St. Louis meeting of the Association of Iron and Steel Electrical Engineers.

arily one of obtaining a motor large enough to do the work. These drives, however, are a small percentage of the total number required to handle the entire mill. Therefore the increased cost due to the large motors on these drives need not necessarily condemn their use. Typical sets of ac and dc motor curves supplied by the manufacturers are shown in Figs. 1 and 2.

A study of these characteristic curves shows no reason why one could not be substituted for the other, provided care is taken in substituting the ac motor for the dc motor to make sure that the maximum torque required in the particular operation will not exceed the maximum torque for which the ac motor is designed. If the ac motor installation is to be compared with the dc series motor operation, we have the added advantage of the constant speed feature making it possible to lay out the gear ratios and determine the resultant table speed accurately. In the case of the dc series motor on account of the speed varying with the load, it is not possible to predetermine the resultant table speed so accurately. The ac motor also has advantage in the fact that it is impossible to abuse the same to the degree it is possible to abuse the dc series motor, due to the fact that the ac motor if severely overloaded stops entirely. The fact that a table load due to the condition of the bearings, lubrication, etc., varies considerably from time to time



makes the constant speed ac motor desirable. However, since the speed is maintained nearly constant under all conditions more care has to be exercised to see that no undue heating takes place, as the increased load on the motor does not show up as apparently as with the series motor. With the series motor the overload shows up in reduced speed of which the operator immediately complains.

As a basis of comparison the writer has taken a few typical motor drives, analyzed and compared them, as to the size of motor required and the cost of installation when equipped with both ac and dc series motors. Curves were taken with curve drawing ammeter and the operating cycle determined. The first installation to be considered is what is known as the front roughing table in a continuous light rail mill while rolling a 60-pound rail. The curve shows each pass to be between three and four seconds duration with the power off the motor during the cycle for no longer than periods of 1½ seconds. The curve shows that the load was one of acceleration entirely

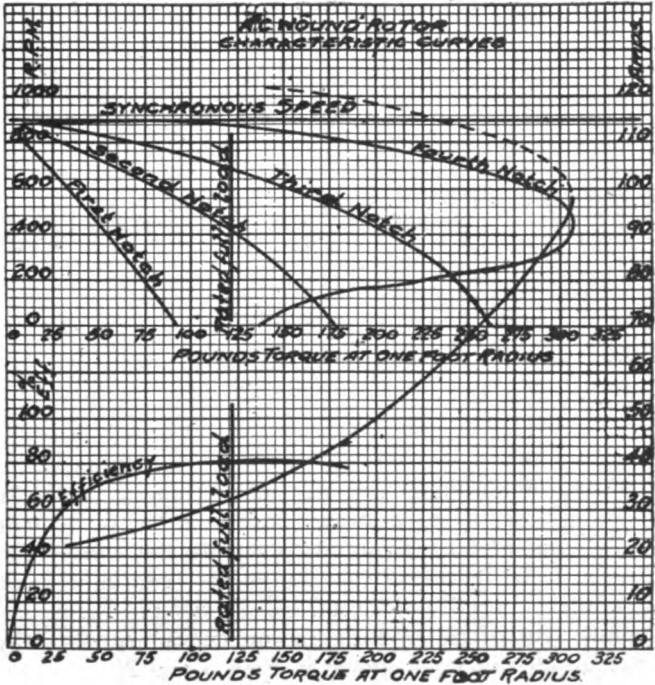


Fig. 1.

as the motor does not attain at any time free running speed.

The horsepower computed from this curve by the root-mean-square method figures out approximately 28.5 for a time consisting of four typical operating cycles and to be safe the motor was selected assuming that the mill operates on this cycle for a period of three hours. This results in a 40 horsepower motor on a one hour rating. The corresponding ac motor will be one which will deliver 45 horsepower at its one hour mill rating. As a further check the maximum torque required was found to be 1,225 foot-pounds, while the maximum ac torque available from the selected ac motor is 1,280 foot-pounds.

Assuming the cost of installation of the dc motor to be 100 per cent, the cost of installing the ac motor will be approximately 132 per cent, divided as follows in each case:

| D. C. Installation    |          | A. C. Installation    |          |
|-----------------------|----------|-----------------------|----------|
|                       | Per Cent |                       | Per Cent |
| Motor .....           | 49       | Motor .....           | 69       |
| Control .....         | 30       | Control .....         | 40       |
| Wiring Material ..... | 13       | Wiring Material ..... | 13       |
| Labor .....           | 8        | Labor .....           | 10       |
|                       | 100      |                       | 132      |

It will be noted from this that the increased cost is due largely to the cost of the motor and controller. The installation labor and material running about the same in either case, assuming that a 220-volt ac motor is adopted. In each the control is assumed to be magnetic.

The next case to be considered is what is known as the back roughing table in the same mill. Carrying the

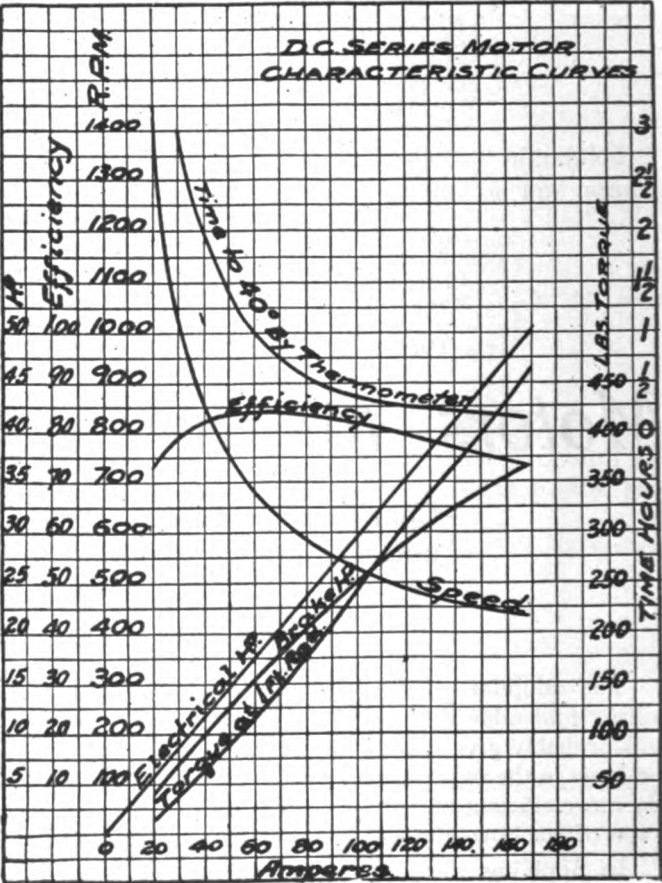


Fig. 2.

calculation through in the same manner as in the first case, we find the cost of one compared with the other will be approximately as follows:

| D. C. Installation    |          | A. C. Installation    |          |
|-----------------------|----------|-----------------------|----------|
|                       | Per Cent |                       | Per Cent |
| Motor .....           | 50       | Motor .....           | 75       |
| Control .....         | 30       | Control .....         | 35       |
| Wiring Material ..... | 13       | Wiring Material ..... | 13       |
| Labor .....           | 7        | Labor .....           | 8        |
|                       | 100      |                       | 131      |

The increased cost as before is due almost entirely to the cost of motor and controller.

Another drive to be analyzed is the roughing table in a sheet bar mill. This cycle consists of one pass and the severe plugging to bring the table to rest. The duration of the pass is from 2½ to 3 seconds with a 20 second rest period. The drive as figured out by the

root-mean-squared method computes 5 horsepower and on a three-hour basis would demand an 80 horsepower one-hour mill rated motor. Assuming that the standard 75 horsepower one-hour mill rated ac motor would handle the work satisfactorily, the comparative cost would be as follows:

| D. C. Installation    |          | A. C. Installation    |          |
|-----------------------|----------|-----------------------|----------|
|                       | Per Cent |                       | Per Cent |
| Motor .....           | 56       | Motor .....           | 60       |
| Control .....         | 29       | Control .....         | 32       |
| Wiring Material ..... | 11       | Wiring Material ..... | 9        |
| Labor .....           | 4        | Labor .....           | 4        |
|                       | 100      |                       | 105      |

In this case the difference in first cost is not very great as the two motors selected correspond almost exactly in size and price.

The last drive to be considered is the front mill table in a 132-inch plate mill. This duty is severe and the periods are all of short acceleration. The table is subjected to severe plugging as the piece must be in the rolls as much of the time as possible in order to get out the tonnage. The total required horsepower from curve is between 38 and 39 horsepower. This on a three-hour basis will require a 50 horsepower one-hour mill rated motor, and on account of the severe service the conditions will probably be met more satisfactorily by adopting a 75 horsepower ac motor as the margin of safety in this class of work should be large to insure continuity of service. A 75 horsepower ac motor of this type will develop a maximum starting torque of 1,540 foot-pounds, while the maximum torque required as shown by the curve with the dc motor operating is 1,500 foot-pounds. The comparative cost under these conditions will be as follows:

| D. C. Installation    |          | A. C. Installation    |          |
|-----------------------|----------|-----------------------|----------|
|                       | Per Cent |                       | Per Cent |
| Motor .....           | 60       | Motor .....           | 75       |
| Control .....         | 28       | Control .....         | 42       |
| Wiring Material ..... | 8        | Wiring Material ..... | 13       |
| Labor .....           | 4        | Labor .....           | 6        |
|                       | 100      |                       | 136      |

From the above analysis it can be seen that the increased first cost of the ac installation would be above 20 per cent for the complete mill, varying of course to a marked degree with the number of drives and the nature of the work for which the mill is designed. If the mill contains a large number of drives which are subjected to severe plugging and rapid acceleration, the increased cost no doubt will be considerably more than 20 per cent.

The drives upon which engineers are reluctant to adopt the ac motor are primarily the tables on either side of the mill proper, due to the rapid acceleration and severe plugging to which they are subjected. The last case considered above is a table of this type. For this reason on this particular drive the 75 horsepower motor is selected when a 50 to 60 horsepower dc motor handles the work satisfactorily. While drives of this type do not as a rule represent more than 15 per cent of the total installed motor horsepower, they may represent as high as 60 per cent of the total load on the converting apparatus and mill feeders, and therefore to equip these drives with dc motors and the remainder with ac motors, the gain in operating economy is liable to be very slight, making it necessary to consider other factors than those pertaining to the relative operating characteristics of the two types of motors. Assuming that sufficient converting capacity is

available at a distance of, say 2,000 feet, and the cost of this 2,000 feet of line is taken at 100 per cent, the cost of an ac, 6,600-volt line and the necessary transformers would be approximately 145 per cent of the cost of the dc transmission line alone. This difference in the first cost must be offset by the increased operating economy obtained by the use of the ac system. Of course, this difference in cost of operating the two systems can be readily arrived at if the mill operates continuously, however, this is liable not to be the case with the result that the ac investment charge goes on continuously while the operating economy made possible by this investment charge can only be realized during periods of actual operation. If, however, converting capacity for dc motor operation is not available, the cost of installing the necessary transmission line and converting apparatus will probably run over 200 per cent of the cost of the ac transmission line and transformers, representing a case where the first cost and operating economy are both in favor of the ac motor installation. If the proposed new mill is being erected adjacent to a dc mill already operating the converting apparatus could readily be used to help out the other in an emergency giving a flexibility of operation which could not be obtained with one mill operating on direct current and the other on alternating current. The same also applies to spare motor parts and control equipment. The investment represented by such being in a good many cases quite considerable.

If sufficient converting capacity is available to take care of the more severe operations the remaining drives can without doubt be handled more economically and just as satisfactorily with ac motors. If additional converting capacity is to be installed and the required capacity would warrant the purchase of converting apparatus, duplicate of that already in service, which could be handled with no additional operating expense, such as labor, etc., and which machine could then be available for other service, it might still be advisable to install dc motors on not only the harder work drives, but on the entire mill even though the apparent economy was less.

It therefore appears unwise to take a definite stand in favor of either type of motor. Local conditions must govern almost entirely. The dc mill type motor has been developed to a very high degree of perfection, not so much from the standpoint of efficiency (meaning ratio of output to input) as from the standpoint of year-around operation, taking into consideration the ability to stand the wear and tear mechanically as well as electrically, together with the manner in which armature changes can be made with the minimum of mill delay. Any shortcomings which the ac mill type motor may have at the present time will no doubt be overcome just in proportion as their adoption is increased. We all know that the dc series motor is the ideal one for rapid acceleration and reversals per unit of weight or per dollar of investment. Therefore, the ac motor will always have this slight disadvantage, however, the mechanical defects which, in considering this subject, should be considered as mere details, have been corrected as fast as they have developed. There is no doubt that the ac mill type motor has not been used enough so that we would be justified in a statement that it is on a par with the dc motor mechanically as yet.

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# Foreign Steel Standards Compared to Ours

## Methods of Physical Testing Much More Exacting Abroad Than in This Country—Comparison of Methods of Heating Forgings—Notes on Foreign Melting Processes.

By MAJ. F. F. MacINTOSH.

### PART II.

The first article of this series appeared on page 432 of the September issue of THE BLAST FURNACE AND STEEL PLANT.

By the practice of a long slow heat, and an effort to heat the forging just above its critical range for quenching, we are in danger in two respects:

1. By using too long heating time we may bring the forging above its critical range and hold it there for a long time, which would result in coarse structure;

2. By using a temperature as we do, just above the critical range, we may not have the entire forging above the critical range when it enters the quenching medium.

Either of the above results gives unsatisfactory metal.

On the other hand, the English practice—short time in the furnace and temperatures well above the critical range when it enters the quenching medium—insures that the metal has not been held for a long time above its critical point, and results in less free ferrite in the quenched metal. The higher temperatures used in English practice are not sufficiently high to cause a serious coarsening of the structure during the short time they are held at that temperature. There seems to be very little fear of rapid heating injuring a forging which has been annealed and rough machined. The annealing has relieved strains and the rough machining has removed surface conditions which might promote cracking or tearing.

The author pointed out that the methods of physical testing are much more exacting and searching than they are in this country. Examination of the records of the Sheffield district for one month showed that out of 5,000 forgings tested 89 per cent passed on the first test. Foreign governments are not willing to accept high grade ordnance material solely on the tensile test. They use the bending test and the impact test is used to some extent although this method is not very popular with the manufacturers. The universal method for test metal used abroad is to cut off a disk at the end of the forging.

The performance of nickel-chrome steels under this test gives a striking example of just how searching it is. For example: A nickel-chrome steel which has been quenched and drawn and cooled in the furnace, or in air after the drawing operation, may meet the tensile and the bending tests with perfect satisfaction, but will fail under the impact test. The same steel quenched and drawn under the same conditions,

but cooled rapidly in oil or water after drawing, will meet all of the tests, including the impact test; that is, the impact test is the only one which is searching enough to bring out the differences between these two steels of the same composition—steels which vary in their ability to resist shock merely as a result of the heat treatment which they have received.

The most common difficulty appeared to be with forgings which failed on the bend test. Failure of this kind usually gave a banded fracture on the broken test piece. Frequently, on forgings of this kind, the tensile tests would be satisfactory but would show a slight tendency toward a banded fracture. There are some differences in opinion as to the cause of this banded fracture. Some metallurgists claim that in all cases where the banded fracture occurs, the steel would be found to contain inclusions of foreign material. Those who held this point of view claim that the difficulty could not be remedied by heat treatment. Certain manufacturers quite naturally held a different point of view on the subject, and their point was well sustained.

I was shown by some of these manufacturers, microscopic studies of the steel which gave the banded fracture, and the evidence presented clearly indicated that it was a segregation such as is quite common in nickel steel. It was a segregation unaccompanied by appreciable amounts of foreign material, and one which they claim could be and was frequently remedied by drastic heat treatment.

Those who hold to the foreign inclusion theory claim that the reason forgings of this kind pass tests after heat treatment is that the test pieces on retest are taken in a new portion of the metal and the portion which happens to be free from foreign material. It is one of those interesting problems over which metallurgists will develop warm discussions for years to come, unless a careful and exhaustive investigation should bring out a well defined solution of the difficulty. The English manufacturers were familiar with the defect which in this country is called a flake. In the Sheffield district it is spoken of as a "zed" fracture—"zed" being the English for the letter Z, standing for an unknown quantity. This defect is of rare occurrence, but most manufacturers had evidently met with it occasionally. There seem to be almost as many explanations for the defect as there were metallurgists who had experience with it. There was only one point in which they all seem to agree and that was the fact that it is associated with inclusions of foreign material.

Careful observation of the machining, and particu-

Second installment of paper read by the author before Engineers Society of Western Pennsylvania.



larly the finished operation on the English forgings, disclose a remarkably clean metal free from sand splits and slag inclusions. The cleanness and freedom of the English steels from inclusions, when compared with our American steels on the same class of work, make it very doubtful if our steels would meet the bending and the impact tests which the English steels are meeting. It requires a very clean steel to meet these tests.

The point which interested me above all else in the French steel making was the fact that under the pressure of war the French had been making some of their cannon steel in basic open-hearth furnaces. As far as I could learn, the steel so made was proving entirely satisfactory.

In order to make satisfactory high-grade steel in the basic open-hearth furnace, the French had developed a method of handling the furnace which resembled in many ways the acid practice. In their basic practice for steel of this kind, the steel was deoxidized and additions were made in the furnace. The metal was never taken out of the furnace until it was demonstrated by chemical and by forging tests that it was thoroughly deoxidized metal. The only additions which were made in the ladle were small amounts of ferro-silicon. Most of their ferro-silicon was added in the furnace.

In order to operate a basic furnace under these conditions, it was necessary to remove a greater portion of the slag before any effort was made to deoxidize the metal in the furnace. I believe that the use of basic steel for high-grade forgings of this kind is a step in the right direction.

I should like to see the methods of testing ordnance steels developed to the point where the Ordnance Department can rely entirely upon its physical and chemical tests for the determination of the character and suitability of the metal for the purpose for which it is to be used. I believe that it is altogether feasible to develop the department's testing methods to a point where this is possible, and where it will be possible to eliminate all unnecessary restrictions upon the manufacturer. Under these more or less ideal conditions, the manufacturer would be free to make the steel in any kind of a furnace which he should choose. He would be free to cast it, to forge it, and to heat treat it in any way that he should think best, and the final test of the Ordnance Department would establish whether or not the material was satisfactory for the purpose for which it is intended.

This elimination of process inspection and requirements may sound very attractive to the manufacturer, but he should stop and consider the fact that it would mean tests much more searching than the ones which he has been facing. I am convinced that much of the steel which is being accepted on tensile test under present specifications would fail if subjected to bend and impact tests. These two tests are very searching as to the condition of the metal, and the presence of inclusions.

French acid open-hearth practice does not differ materially from the English, except that some manufacturers seem to be even more particular about the

condition of the slag than were the English steel makers. I found French slags in some instances running as high as 65 per cent silica, and when samples of the slag taken during the making of the steel showed a black streak, the slag was considered to be too high in free oxides.

The French were using nozzles somewhat larger than those used in England. The French practice seemed to vary between 1 and  $1\frac{3}{4}$  inches, and it was almost a universal practice to teem through some kind of a basket. The steel was what we would call very hot steel and left no skull in the ladle. All large work was top poured with hot tops. Bottom pouring was used only for nests of small ingots where it was particularly desired to secure a good surface on the ingot, or where it was desired to save time in teeming.

One of the manufacturers was bottom pouring 20 ingots at one time. These were individual ingots, each one to be worked into a tube or jacket for a 75-mm gun. This is the only instance in either country, where I found bottom casting employed for cannon forgings. The same general opinions seem to be held in France in regard to bottom pouring as were held in England.

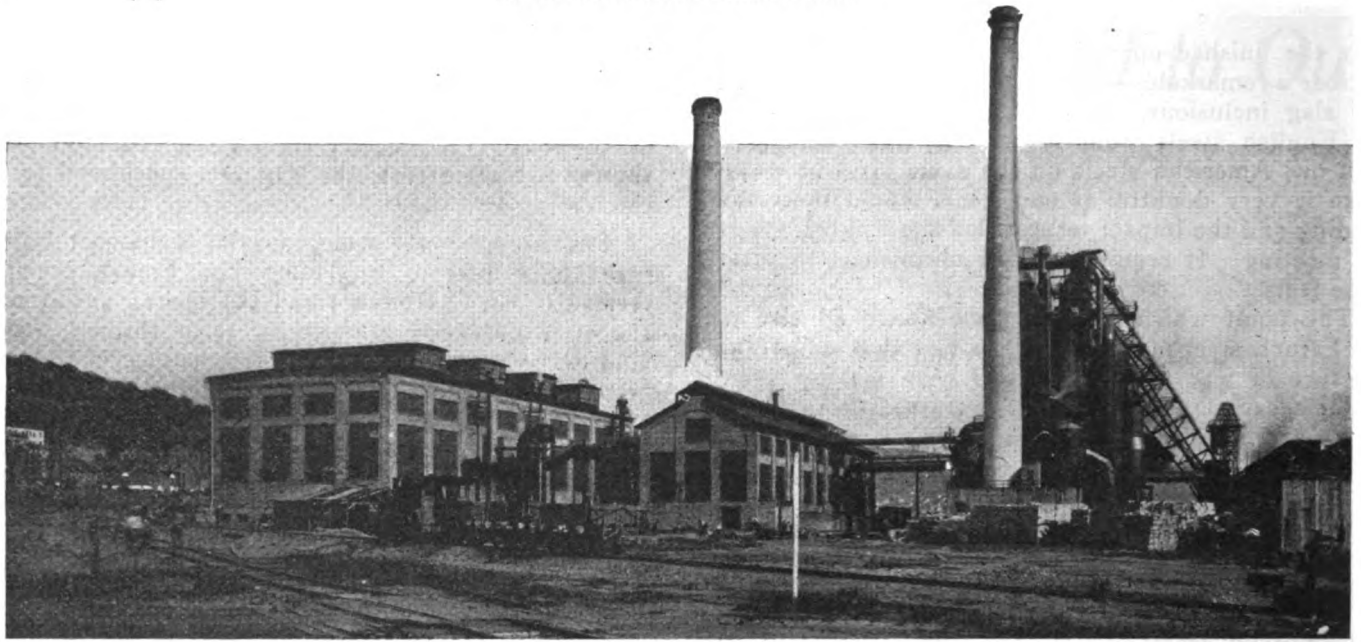
Steel for large forgings is usually heated to about 1,150 or 1,200 degrees C. for forging. These temperatures in most instances are checked from time to time by means of an optical pyrometer.

The general practice in France seemed to be to heat the steel somewhat more slowly for quenching than was the practice in England. For example: On 155-mm. gun tubes, three hours were taken to bring the tube up to temperature, and it was held at that temperature for about 30 minutes. The quenching temperatures used were, as a rule, higher than those which were being employed in this country. It is quite common to find 850 degrees C. as the temperature for quenching, and it was generally felt that where this temperature was used, 50 degrees C., one way or the other, made very little difference. Most of the quenching was done in water.

The French regularly require a bending or impact bending test, and their experience with this test parallels that of the English; i. e., steels which are not in the proper condition, or which contain numerous small foreign inclusions may pass on the tensile test, but cannot pass the bending test.

The Charpy impact test is used merely for special investigation and is not a regular inspection test except upon material for aeroplanes.

When I attempt to summarize the situation from the point of view of an ordnance officer, I hope that it will be definitely understood that I am merely giving the personal opinions and ideas which have developed as a result of service in this country as a metallurgist with the inspection division of the Ordnance Department, and as a result of service as a liaison officer abroad. I regret to say that no official sanction or weight is to be given to any of my observations or ideas on the subject.



## Weirton Blows in New Blast Furnace

**Blast Furnace Plant at Weirton Steel Company Designed for Future Extension—Will Operate as Merchant Furnace Pending Completion of Open Hearth and Steel Works.**

The first blast furnace of the Weirton Steel Company was blown in July 21, 1919, following a construction period of 364 days, ground having been broken July 22, 1918. The ground upon which this furnace plant is located adjoins the Chester branch of the Pennsylvania Railroad, near the main line between Pittsburgh and Steubenville. The Ohio river forms the north boundary of the plant, general yard level of the plant being 88 feet above the river.

It was apparent that for the first 12 to 18 months of the blast and pending the completion of the open hearth and steel works, the plant would operate as a merchant furnace, after which it would revert to an operation tied in with by-product coke ovens and the exigencies of modern steel plant practice. It also had to be provided that the first furnace plant units were capable of expansion, without any interruption to operations, into a plant of three furnaces, about which the growth of the original bins, tracks, boiler and power house units would group symmetrically with the minimum compromise between a well synchronized three furnace plant operation and the initial expenditure and operating costs for the first furnace and its auxiliary equipment. To these desiderata, was imposed the requirement that all steam and power generation and pumping facilities for the entire furnace and steel plant, exclusive of open hearth waste heat boilers, were to be concentrated at the blast furnace blowing room or power house. To be kept in mind moreover, were the basic requirements particularly true for an initial operation for a modern furnace, that the maximum tonnage must be produced with the greatest economy in coke; that the ma-

terials of burden and the supplies, products and by-products of the furnace operations must be handled with least expense and utmost facility; that the labor be held to a minimum; and that the maximum power from excess furnace gas be realized.

This data is given to afford a point of view from which the reader may value the design and the manner in which the initial furnace plant, with its auxiliaries, was constructed.

No. 1 furnace is 92'x22'-6", and the capacity from tap hole to bottom of bell is 25,500 cubic feet. The thickness of lining is heavier at the bottom with a view to affording maximum thickness where required and giving moderate thickness where excessive depth of lining is detrimental. No interior water cooling is given lining above the mantle but a permanent pipe spray with connection is affixed to the shell. Six rows of bosh plates are placed in the bosh wall; the tuyere breast is cooled by two plates between and flush with the top of the cooler arches, one plate between the cooler arches, and two rows of plates beneath the cooler arches. The hearth walls are cooled by the cast-in cooling pipe of the hearth jacket. The stock line is afforded protection by cast iron wearing plates of high combined carbon content. These plates are laid integral with the lining and are of small surface dimension in each unit. Lining is made up of General Refractories Olive Hill brick.

The iron and steel work of the furnace consists of a heavy continuous cast iron sub-base, with heavy anchor bolts from iron sub-base to concrete foundation. The concrete foundation for the column base is reinforced by tension bands which encircle it on



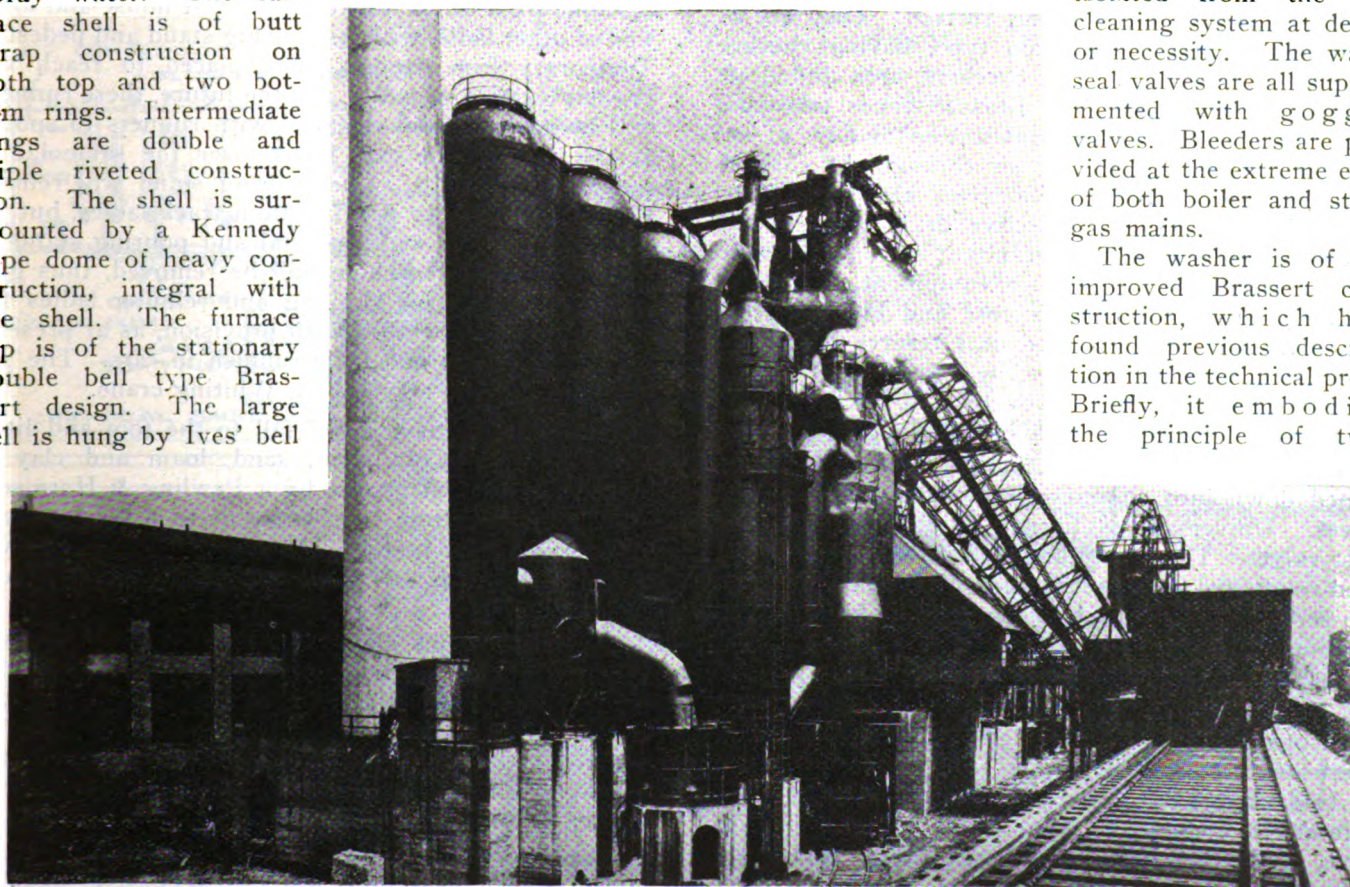
the outside, and the column base and columns are reinforced by a tension band at the column base and by reinforced concrete encircling the base plates and columns. The columns are encased in firebrick. There are 10 columns, cast iron, and cast in two sections. The columns are placed in a leaning offset position, the diameter of base circle being greater than the diameter of top circle. This is to afford room for work about tuyeres and plates, to place columns at a more remote location from possible breakout, and to afford possibility of enlargement. The bustle pipe, circle pipe and trough are hung from the top segment of the columns by means of riveted or cast on saddles. This arrangement, together with special design of circle pipe inlets and trough overflows, gives a walk on bustle pipe for access to three-way cock and water discharges entirely free from suspension strap or pipe interferences.

The hearth jacket is of cast iron segments, 16 in all, with pipe cast in. It is heavily wedge banded and bolted. Taper construction is used to maintain safe thickness of hearth walls against erosion and to maintain ample brick at the bottom for avoidance of short-holes. The tuyere breast is of butt strap plate armored construction, with 10 cast steel tuyere cooler frames. The bosh is reinforced with heavy steel butt strap bands, the bands being held by cast steel distance pieces to prevent slipping. The mantle is of built-up plate and angle construction and is provided with a trough with drainage connections for collecting shell spray water. The furnace shell is of butt strap construction on both top and two bottom rings. Intermediate rings are double and triple riveted construction. The shell is surmounted by a Kennedy type dome of heavy construction, integral with the shell. The furnace top is of the stationary double bell type Brassert design. The large bell is hung by Ives' bell

suspension. The top is laid out with particular reference to abrupt and correct assumption of dumping position of skip, high dumping speed of skip, adjustable skip lip and deflector plate, adjustable centering of hopper and bells, and with volumetric proportions of throat and hopper and areas of bells worked out by combined experimental layouts and practice results. The gas is taken off by four off-takes from an annular gas space about the big bell hopper, which both reduces average gas velocity and eliminates segregated velocity areas above the stock and past the bell lip, which reduces production of flue dust. These off-takes combine into four uptakes, two of which are surmounted by Baer safety valves. From these uptakes are led four downtakes, each two combined into one downcomer. The two downcomers enter the dust catcher radially. The gas leaves the dust catcher at the top, where there is provided a gas bleeder valve, and passes to a Brassert Witting tangential whirler. From the whirler the gas is passed through a Brassert washer with vertical water seal separator, and thence to the stoves and boilers. A by-pass is provided so that gas from the whirler may be sent direct to the boilers rough-cleaned, the gas for the stoves only being passed through the washer, or so that in necessity, rough-cleaned gas may be sent to both stoves and boilers. Water seals are provided so that stoves or boilers may be singly or combinedly shut off from the entire cleaning system or furnace at cast or shutdown, and so that the wet cleaning may be

isolated from the dry cleaning system at desire or necessity. The water seal valves are all supplemented with goggle valves. Bleeders are provided at the extreme ends of both boiler and stove gas mains.

The washer is of the improved Brassert construction, which has found previous description in the technical press. Briefly, it embodies the principle of two-



View of blast furnace plant showing stoves, Brassert washer, Heine brick lined reinforced concrete stack and self-supporting skip incline.



stage scrubbing, combining a first cleaning stage to eliminate the rougher and heavier portion of the dust and to effect cooling, followed by a second stage in the same tower to eliminate fine dust and fume. The gas entering at the bottom is distributed by a perforated inverted frustrated cone, passes through three banks of superimposed offset baffles. All water is introduced in at the top baffles in the form of a heavy spray, the arrangement of nozzles and sprays being such that gas and spray are churned into intimate contact. The spray coalesces into rain in the baffle chambers and falls through the tower, its descent being impeded and distributed by the lower hurdles. A pronounced increase in retention period of water in scrubber and consequent economy in water and high cleanliness of gas is effected. A special characteristic is ability to handle heavily dust laden gas from rough working or slipping furnaces. The water seal separator is a receiver that gives the gas three alternations of acceleration and retardation in velocity, in combination with simultaneous reversal of direction of flow. It is used both to remove entrained water carried by gas from washer and as a water seal after the washer. Long experience with this type of cleaner has demonstrated a reliability, utility and dependability which more than compensates in practical operating practice for the actual loss of 4 per cent in heat abstracted from the gas.

The Dougherty system of steam for prevention of gas explosion is used on the gas main system.

The stoves are three in number, 22'x100', of a total of 285,000 square feet heating surface. They are of the two-pass side combustion type, having checker openings 3½" square. The checkers, arch and draft chamber design follow the Brassert-Jones construction. This design forces equalization of flow of ascending gas and descending air through the checker openings, and overcome tendencies always encountered of segregation or selective draft areas in the checker opening area, with resultant hot and cold idle checker segments. This stove equipment, due to its relatively high heat transfer rate and low radiation loss, gives all blast heat and heat reserve for 45,000 cubic feet wind volume. The stove is insulated throughout with Sil-O-Cel powder and brick, and the blast mains with Johns-Manville thermo fire felt.

The stove trimmings include blow-off valves turned down into chimney draft flues, two chimney valves. Universal gas burners, and Mathesius hot blast valves. The stoves are served by a Heine brick lined reinforced concrete stack, 9' 6"x225'. This stack also serves the next block of stoves to be built in conjunction with No. 2 furnace.

The cold blast line is provided with steam connection for extinguishment of fire and also has its snort valve opening turned down into chimney draft flue. There are two counterweight blast relief valves on the cold blast line. The by-pass enters the hot blast main at No. 3 stove and is provided with gate shut-off valve, McCarthy check valve, and butterfly regulating valve. This is operated from cast house, the lever being in proximity to hot blast temperature indicator.

The level of the stove foundation top and cast

house floor are at the same elevation. The dust catcher and whirler dust bell platforms, control valves for water at water seals and washer, control valves for steam in dust catcher and gas main, main water supply valves and by-pass, are all operated or accessible from this elevation, thus enabling the general foreman to maintain supervision of stoves, water, dust catcher and washer attendance, and practice with mixer valve, without the deterring handicap of ceaselessly climbing up and down steps. The same elevation of stove operating level with cast house will in the future provide a thoroughfare for foremen and maintenance gangs and material between all three furnaces. Yard is reached by steps midway between stoves and furnace, steps at end stove platform, steps midway of stoves and furnace to skip house, and thence to bins or yard.

The cast house had to be laid out with the end in view of running metal direct to the pig machine while the plant was operating as a merchant furnace; but to eventually run to track ladles for delivery to open hearth mixer, with the pig machine in the same location available for use for off-grade and week-end metal. This was worked out by placing a Pittsburgh coal washer double strand casting machine at the bottom of the cast house; two Pollock short pour ladles (with spare) were placed one at each side of the machine. The ladle furthest off-center had its pedestal and pouring stand placed in the location of the future track that will bring hot metal cars to the casting machine from all three furnaces. This located the center line of pig machine from center line through cast house and location of other ladle, with its pouring stand and pedestal. Temporary iron runners were placed to reach the present location of ladles. In the future, these runners will be removed and replaced with runners to spouts at the side of the cast house over the same ladles mounted on trucks. The pouring stand will remain at the east side, for pouring from track ladles, but its pedestal together with pedestal and pouring stand at the west side of machine will be removed, thus giving ample room for skulling and relining ladles for three furnaces, together with provision, as at present, for placing scrap and ladle rubbish in cars. The pig machine house is served by a Whiting crane.

The runners have a ⅝" fall to the foot and little scrap results. Coke dust, sand, loam and clay is brought to the cast house by a Pawling & Harnischfeger monorail from bins adjacent to a track at the base of the cast house. The monorail also removes cast house scrap and rubbish, handles tuyeres and furnace tools.

A Berg-Brosius clay gun is provided. This was specified not only from a safety standpoint but also in view to keeping the blast on the furnace and gas at the boilers to the maximum over costs in view of the heavy outside power load. But one cinder notch is provided, this being 45 degrees from the iron notch. Cinder is for the most part granulated, a deep pit being provided. This is served by the Pawling & Harnischfeger monorail. Six cars can be spotted under the monorail. A Brosius single line bucket is provided for handling the granulated cinder. Provision

is also made to use cinder ladles, spouts being placed to accommodate them. The shutters are all of the remote control type, the furnace can be rodded from the cast house, snort valve wheel, gun control and shutter control are all located as a unit, duplex signal apparatus is provided between cast house and stock house, boiler house and power house. Special lighting facilities were provided and an abundant number of hose connections for both high and low pressure water. Both steam and air are piped to the cast house for use on the gun and for other casual requirements.

Water for the furnace bosh, gas washer, pig machine, cinder pit and miscellaneous uses is supplied through two independent lines from the pump house, with cross connections for emergency use. The circle pipe is fed by duplex feed lines provided with Elliott twin basket strainers. Auxiliary high pressure line is also in proximity to three-way cocks for blowing out furnace feed and discharge lines and hot blast valves. High pressure and steam lines are also provided at the top of the furnace.

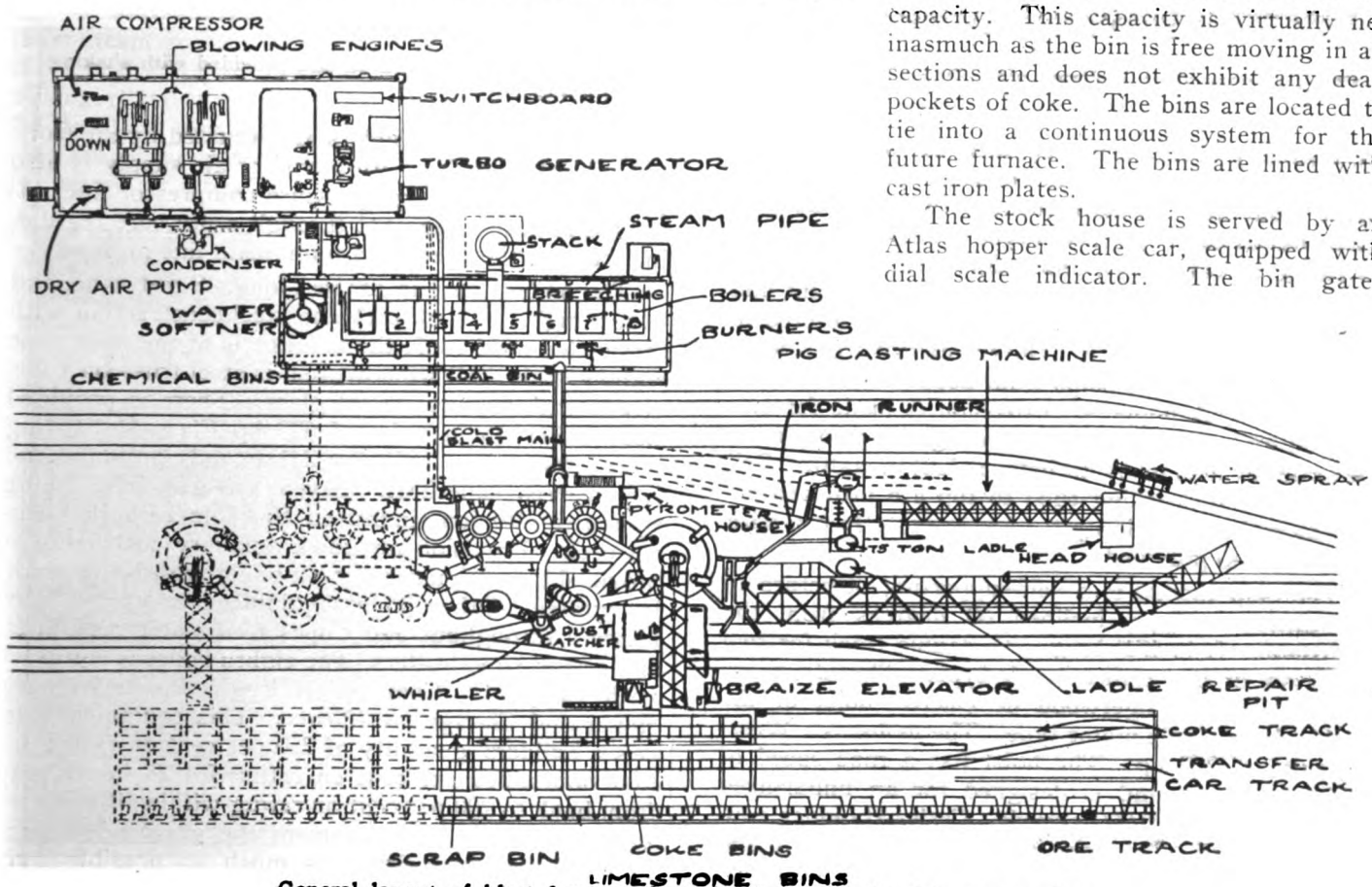
Although the plans included the provision of an ore bridge with movable car dumper, the necessities of the program compelled deferring its installation. Instead two 30-40 Brown cranes with 70' boom and two yard buckets were purchased, to be later used on yard work for the completed steel and furnace plant. These are used with outrigger wheels during the present season, at least, for stocking and reclaiming ore. They have proven able to cope with an unloading rate of 55 to 60 cars per day, including reclaiming ore for bins outside of unloading requirements. Hand

labor, is, however, required at present for unloading cars. The later installation of an ore bridge will be carried out independent of stocking operations as there is provided the necessary ore bridge track rails on the ore bin back wall and its extension. Particular attention was paid to have a well lighted and ventilated stock house. Air ducts are located in central division wall of bins between railroad tracks thus insuring ventilation above scale car. Large opening in every vent on either side of scale car track makes possible a large light storage for spare parts. A 12" concrete base was laid under the car track and the concrete floor encases the wooden ties. The top of floor is brought flush to top of rail on the outsides of track. The concrete between rails was kept down 2" and sloped from the center of track towards the sewer traps.

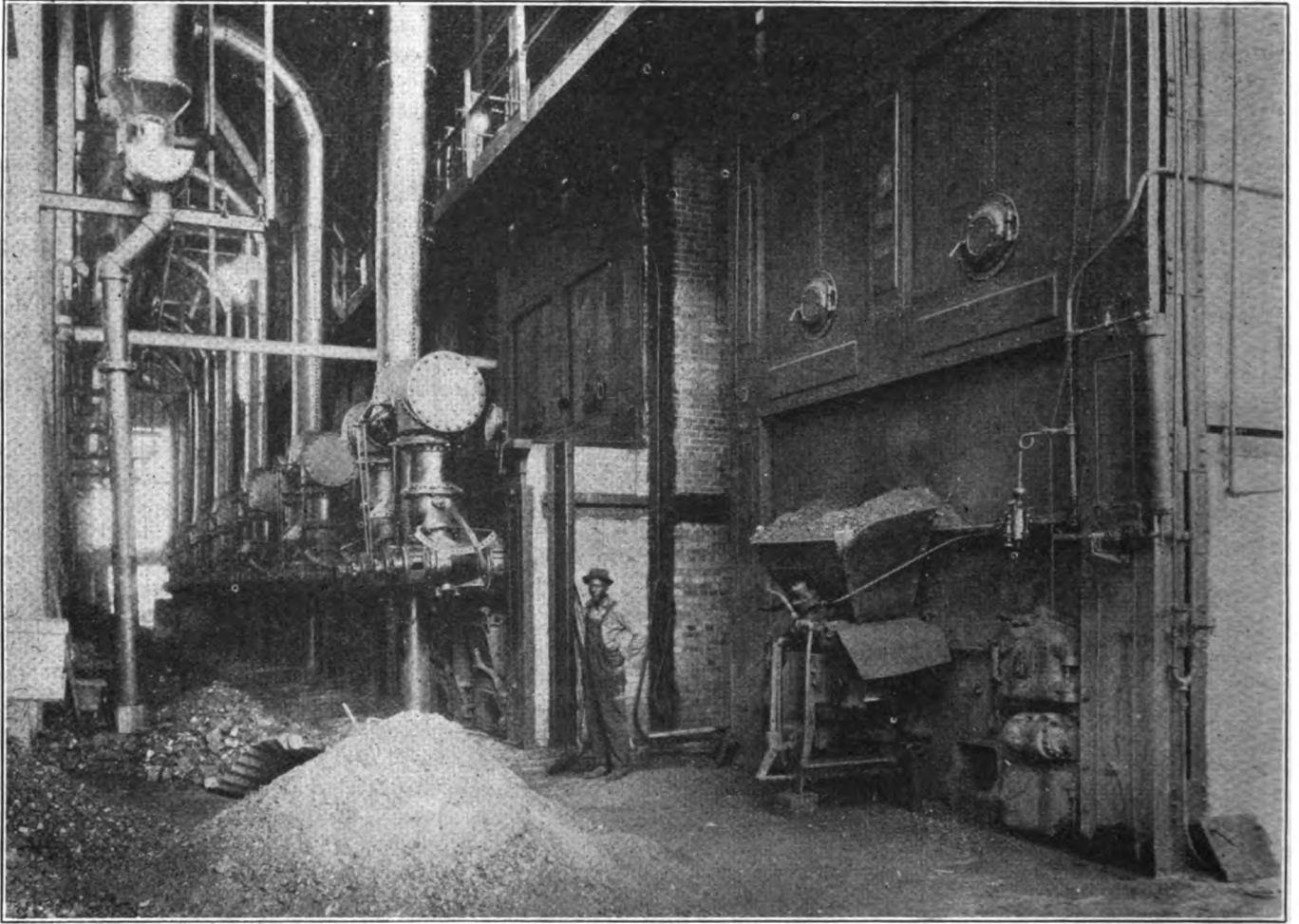
The bins themselves are of the Rawstorne reinforced concrete type. They have an earth fill and trestle approach on a  $2\frac{1}{4}$  per cent grade. From scale car to transfer car rails is 32'. There are two tracks, one track serving the coke, limestone and scrap bins and the other the ore bins. These tracks are supported by Bethlehem type girders across the coke bins while at the other bins the track stringers rest on the concrete bin division walls. The ore bins are served by a Brown 50-ton transfer car, into which ore is loaded by the cranes from stock pile. Each bin has a gross capacity of 200 tons of ore, thus giving (depending upon the rate of driving of the furnace) 40 to 48 hours capacity, or flexibility for eight grades of ores and by-products. The double coke bin has a gross capacity of 270 tons of coke, or from 10 to 12 hours

capacity. This capacity is virtually net inasmuch as the bin is free moving in all sections and does not exhibit any dead pockets of coke. The bins are located to tie into a continuous system for the future furnace. The bins are lined with cast iron plates.

The stock house is served by an Atlas hopper scale car, equipped with dial scale indicator. The bin gates



General layout of blast furnace plant showing plans for future expansion.



4,800 hp boiler plant equipped with 600 hp Stirling boilers. Seven of the boilers are gas fired and provided with shaking grates for auxiliary coal firing.

are manually operated by the scale car men and feed from both sides into the car hopper. Coke is drawn direct from bins to skip bucket, each skip holding 4,500 pounds coke. A Haven type coke screen is used, obtaining a retarded cascade effect over self-clearing screen openings. Both the slope of each element and the effective area of screen opening may be altered to suit the character of coke. The screenings are handled by DePere automatic skips from hoppers beneath the screens to track hoppers. Provision is made for two bell rod and air actuated coke bin gate operation by the scale car man or by an independent operator. Bell indicators and speaking tube to top are provided, as well as siphon for skip pit. An extra scale car with switch is also provided.

The skip incline is a self-supporting structure of the cantilever type, inclined 60 degrees from the horizontal. It is 171' long with double track for two skip cars of the trailer truck type. The skips are operated by a Lidgerwood dc electric hoist of the double drum single motor type. The motor is a Westinghouse of 200 hp. The hoist has a rope speed of 225' per minute and is designed for an unbalanced load capacity of 20,000 pounds. Cutler-Hammer control is supplied. The hoist is located in a concrete and brick house under the skip truss and above the track. This structure also houses the bell cylinders for operat-

ing the bells. The cylinders are actuated by air from the cold blast mains. An auxiliary air supply is also provided from the high pressure compressor line. It is automatically admitted through a pressure regulating valve in the event of drop in main line pressure.

The boiler house is 200 feet long, 48 feet wide, and 42 feet high. It is of brick and steel construction with corrugated steel roof; the monitor is of the open type without sash. All window sash is steel trusscon type, glazed with factory ribbed glass. There is provided 4,800 boiler hp in units of 600 hp Class M Stirling three-pass boilers, built for 231 pounds pressure and 125 degrees superheat. Seven are gas fired, being equipped with four improved Birkholz-Terbeck burners each. Provision for quick auxiliary coal firing is provided by equipment of each boiler with Kelly shaking grates. Other boiler equipment is Vulcan soot blowers throughout and Copes feed water regulators and Foster superheaters. The eighth boiler is equipped with "Type E" Combustion Engineering Company stoker and Clarage fan blower. This equipment carries a builders' guaranty of 250 per cent on rating for four hours, 200 per cent on rating for 24 hours, and from bank to 200 per cent on rating within 10 minutes. It was installed to supplement the gas fired boilers, to eliminate hand firing as much as possible over periods of fluctuating gas supply over cast, and to



meet peak loads on the generator. The boilers are served by a 225'x12' 6" Heine reinforced concrete chimney, connected to the boilers with an overhead breeching of  $\frac{1}{4}$ " plate lined with Johns-Manville insulation. Coal storage bins are arranged for installation of monorail unloading system and foundations are laid out for installation of mechanical ash handling.

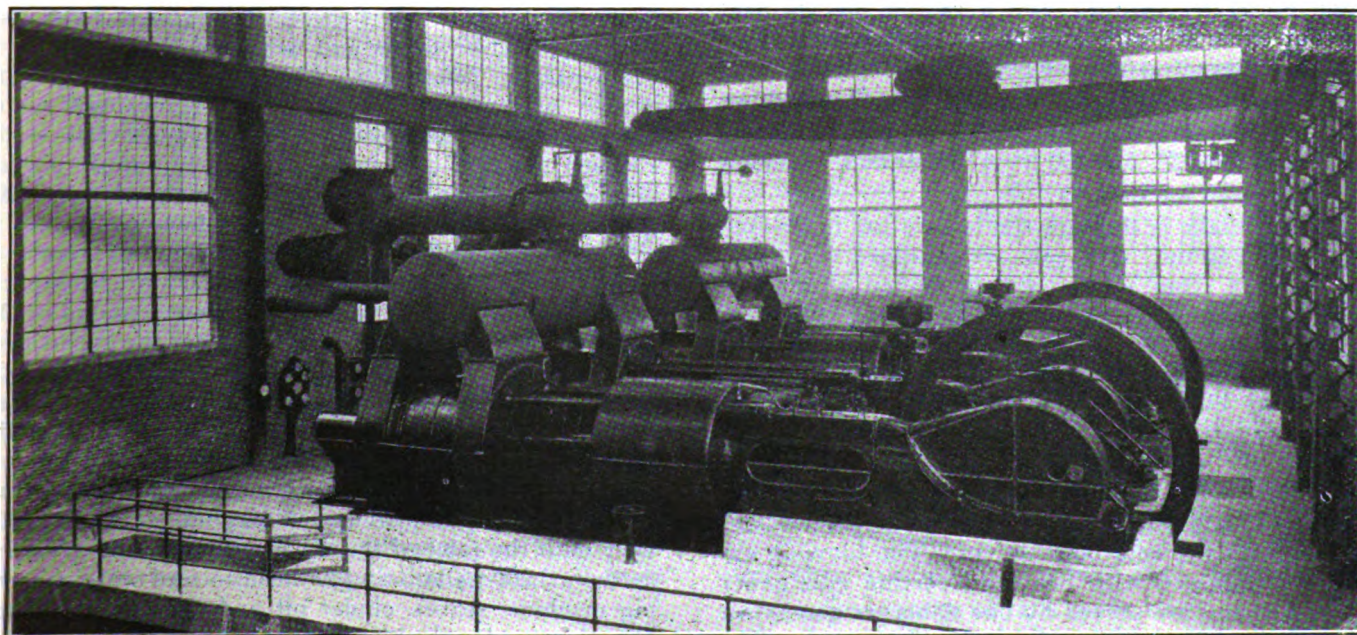
The boilers are placed singly right and left setting, with 6 foot aisles, and with 15 feet in front of boilers. Dust from boiler house gas main is flushed through a trough to the sewer. Approximately 4,200 to 4,350 boiler hp "from and at" is realized with gas from the furnace, driving at a 550-ton rate, and credits per ton pig iron from power from surplus gas are high. This is due both to the high efficiency realized at the boilers where stack temperatures of 550 degrees with  $\text{CO}_2$  content of waste gases of 23 per cent are averaged, and also to the high Rankin cycle efficiency attained at the blower and turbo-generator due to the high pressure and superheat of steam.

Boiler feed water comes from the hot well of the blowing engine condenser at 115 degrees F. with auxiliary supply from the turbo-generator hot well at 95 degrees F., and is put through a Graver combined heater and hot water softener. Chemical treatment is automatically proportioned. An average feed water temperature of 202 degrees F. from the hot water treater is maintained. Centrifugal boiler feed pumps are installed having a capacity of 550 gallons each per minute at 600' discharge head. Worthington three-stage pumps are used, driven by a Moore non-condensing turbine equipped with Fischer governor. The exhaust steam goes to the heater. Other exhaust steam to the heater is from the Clarage fan engine, the blowing engine and turbo-generator condenser air pump and the auxiliary service water pump. The boiler feed lines are in duplicate to obviate any possible shutdown by failure or clogging. The lines are covered with

Johns-Manville insulation. There is an emergency cross connection to the boiler feed lines from a Knowles reciprocating pump. The boiler house, inclusive of building, gas main, steam and water lines, is laid out to permit expansion to the north with additional gas fired boilers for the additional blast furnaces and to the south with additional stoker fired boilers. The latter will form a balancing group to carry fluctuating steam demands against a fluctuating gas supply and to supply any deficit between steam demands for the power requirements of the furnace and steel plants and steam available from blast furnace gas. On the completed plant there will be a theoretical center line between the sources of steam supply and points of steam demand.

The steam lines are in duplicate, consisting of a main header of capacity for entire steam demands of blower, generator, pumps and auxiliaries. It is supplemented by a parallel header tied in at four points so that in the event of replacement of any fitting on the main header, at least six boilers can be tied to power house and cast house operation. The auxiliary line is of a capacity to run the blower and the pumps, with some reserve for partial load on turbo generator. The main and auxiliary steam headers are carried on brackets on boiler house columns up to the end of the house. Here they reach the power house through a tunnel, which also carries service and auxiliary service water lines, high pressure water and air lines and electric conduits. The steam lines in the power house are all beneath the floor level. It is to be noted that the main steam header in the boiler house, with its lead to the power house, forms the first element of the eventual boiler plant where the header will expand into a loop system through the boiler and power house with three cross connections and with steam from the waste heat boilers tying in at the south end. American Ideal steam traps are used.

The power house with following dimensions is 180'



Mesta high speed horizontal cross compound blowing engines.



long, 74' wide, and 38' high, is also of brick and steel. Particular attention was paid to most effective day lighting and to ventilation. The monitors on this roof are in every other bay located parallel to the width of building. The roof is constructed of 2" tongued and grooved sheeting covered with Johns-Manville roofing. In both power and boiler house, attention was given to architectural design, and the buildings are of attractive appearance. Power house equipment is described below:

The turbo generator, a 7,500 kw, 6,600 volt, 3 phase, 60 cycle ac General Electric machine, is placed at the south end of the power house and forms the first of four or possibly five of these units to be located in the extension of the power house southward. The machine was on order by the Weirton Steel Company when the construction of the furnace plant was ordered. Although ordered for lower steam pressure and superheat, slight modifications enabled it to be placed in the blast furnace power house to make available for mill requirements the surplus steam over and above furnace requirements. At the power house is also a 600 kw General Electric motor generator set to furnish 220 dc for blast furnace purposes. The high potential current is distributed to the furnace M.G. set and tied in with other high potential current from the tinplate mill, and thence distributed to the other points at a General Electric switchboard in the south end of the power house. The switchboard is the first unit of the future power house. The 220-volt dc current is distributed to two pumps in the pump basement of the power house between the blowing engine and the power sections and led by conduits to the skip engine house, where the switchboard for the pig machine, monorail crane, skip hoist, scale car and larry car is located. Further leads are provided to switchboards for the ore bridge and car dumpers and to the distributing boards for No. 2 and No. 3 furnaces. Auxiliary equipment at the turbo generator is a Westinghouse LeBlanc barometric condenser and air pump, designed for 28" vacuum, and a carrier air washer; Swartout exhaust heads and Davis atmospheric relief valves are placed on the atmospheric exhaust line.

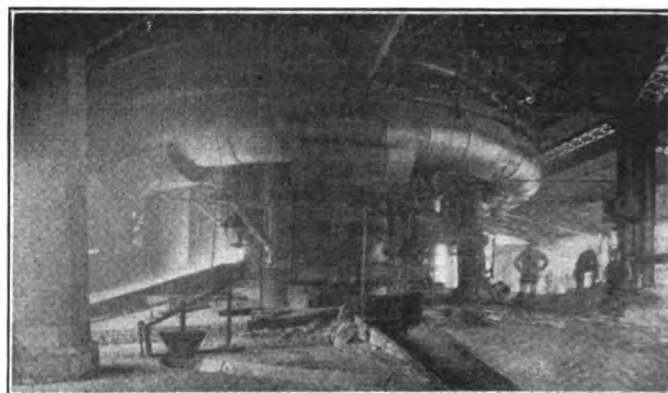
The blowing equipment consists of two Mesta high speed horizontal cross compound blowing engines, 34x72" and 84x48" for 100 rpm maximum. Iverson valves are used on this air tube.

The air intake is through the foundation individual to each blowing tub. The tubs are equipped with common receiver from which the air is led through a Dyblie non-return valve to the blast line manifold. This connects to No. 1 furnace cold blast main with blanks for No. 2 and No. 3 furnaces. Auxiliary atmospheric relief blast valve and line is also provided so that the engine can be turned over and warmed up, and with the cold blast valve open, by closing the atmospheric relief blast valve the blast is thrown on the furnace and the other engine taken off without juggling with the cold blast valves. The blowing engines are equipped with Schutte-Koerting emergency stop valves and are served by one Alberger condenser and dry air pump, designed for 26½" vacuum. The exhaust lines are designed for extension if desired for

interconnection with exhaust lines for Nos. 3 and 4 blowing engines, so that any of three operating engines can be operated on three condensers.

Lubrication is taken care of by a Bowser system located in the basement with tanks on the roof truss. Other power house equipment is an Ingersoll-Rand motor driven compressor for 300 cubic feet free air at 100 pounds pressure, a Champion 25 ton crane, and Alberger condenser and air pump.

The initial requirements for water were: Coke oven plant, 1,200 gallons per minute; turbo generator condenser based on 70 degrees water, 8,500 gallons per minute; blowing engine condenser, 5,000 gallons per minute; blast furnace, 1,500 gallons per minute; gas washer, 1,700 gallons per minute; boilers, 500 gallons per minute; stoves, pig machine, cinder pit, high pressure and miscellaneous uses, 2,900 gallons per minute, or a total of 31,000,000 gallons per day. The initial pumping head from the river to the turbo was 175 feet and the distance pumped was 2,700. Obviously this would have required very excessive size of mains and



Interior view of blast furnace plant.

horse power on pump drive. To conserve on both items there was worked out and installed a unique system. The river pumps were based on 9,700 gallons at 175 feet head. This gave the required 1,200 gallons to the coke ovens and delivered 8,500 gallons to the generator condenser. The water rate in the condenser was specified to give 95 degrees tail water temperature at full load. The condenser tail water escaped through a weir into the main supply cistern beneath the pump room floor. From the cistern 5,000 gallons a minute are delivered by a low head pump to the blowing engine condensers. The water rate is here specified to give a maximum tail water temperature of 115 degrees at full load. There remains of the 8,500 gallons of 95 degrees water from the turbo generator, 3,500 gallons; 32,000 gallons is pumped at 160' head to the blast furnace bosh and to the gas washer. Three hundred gallons is surplus and escapes to the sewer. The 115 degrees water from the blowing engine condenser is returned by means of a weir to just outside of the pump room. A large pipe connects the weir with the inlet of the service pumps, one of which delivers 3,200 gallons at 160' head to feed water heater, pig machine, stoves, cinder pit and miscellaneous use. One thousand eight hundred gallons per minute is sur-

(Continued on page 525)

# Reducing Loss in Steel Rail Manufacture

Detailed System of Inspection Advocated Which Should Thoroughly Supervise the Progressive Steps in the Manufacture of Steel Rails—Cold Straightening—Importance of Composition.

By ROBERT W. HUNT.

It has been the writer's fortune to have been connected with the manufacture of steel rails during the whole of the existence of that industry in America and therefore he has had, from practical contact, an intimate knowledge of the various developments that have taken place in that industry; and, particularly, as during the last 31 years he has made a specialty of steel-rail inspection, he feels that he may claim to have had the best of opportunities to become familiar with the details of the procedure.

This familiarity led him, early in 1912, to recommend to his clients a more detailed system of inspection than had until then been used, which should more thoroughly supervise the progressive steps in the manufacture of the rails; beginning at the making of the steel down through the various stages of manufacture to the loading of the finished rails upon the cars for shipment. On this line, the firm of Robert W. Hunt & Co., at the request of one and with the approval of several others of their more important patrons, established, in 1912, what is known as their "Special Inspection." This consists in placing inspectors in all the departments of the steel works, beginning at the open hearth furnaces or Bessemer converters, at the soaking pits and the blooming mill, the rail mill, the drop-testing machines, the hotbeds, drilling and straightening departments, and, finally, the inspection of the finished rails. These men are placed at each of these several departments day and night, their duties being to observe carefully all the details taking place; and if there should be any deviation from the provisions of the specifications under which the rails were purchased, or deviations from the accepted practice of the mills, or abnormal conditions of any kind, to make note of the same; and while not at liberty to interfere directly with the workmen, to call the attention of the foreman of the particular department in which the occurrence is taking place to what is happening, and also to pass a written report to the inspector stationed in the next succeeding department, and so on to the finished-rail inspectors. The chief inspector is also required to give a written report of unsatisfactory conditions to the superintendent of the mill, so that there may be an absolute record of what has happened to each heat of steel made on either turn, be it day or night, and as the rails are stamped with their heat numbers, and location in the ingots from which they were rolled, the mill management will possess an individual history of each rail, with the possible identification of the individual workmen who were in control of the manipulation of the rail from beginning to end.

From paper read before September meeting of A. I. M. & M. E.

Moreover, a comprehensive report is rendered to the proper official of the railway company for which the rails are manufactured, resulting in the archives of that railroad possessing a detailed history of the making of the rails. Hence, should a rail fail in service, it will be possible to not only have cognizance of all the details of its manufacture, but the makers will be able to determine the workmen who participated in that manufacture. As can be appreciated, this leads to a personal responsibility being attached to every rail. It must be remembered that the workmen at the mills are paid by the ton, hence they are naturally desirous of producing as large an output as possible, and under the ordinary system of inspection, as soon as the rail left the works, all individual connection with it vanished, or, at best, any process of personal connection was extremely difficult and uncertain.

The result of this special system of inspection has been most satisfactory to both the manufacturers and the purchasers, and it receives the approbation of the workmen themselves, as each man knows that if he properly performs his duties, he is protected against the danger of being held responsible for the acts of a less careful operative, while the mill management has given it, without cost, a thorough system of supervision. That it has proved satisfactory to the railway companies, who have been employing it, is best evidenced by the records of the American Railway Engineering Association.

As each ingot is a separate and individual casting, I believe that, in addition to the tests representing the whole heat of metal, there should be some way of determining the physical character of the steel rolled from each and every ingot. As a destructive test seems to be the only way to actually ascertain that point, and as, of course, you cannot destroy all the rails, I, in 1915, installed what is known as the nick-and-break test, under which a test piece is cut from the top end of the first, or A, rail rolled from each ingot. This is nicked and broken, thus enabling the inspector to examine the fractures and, in case of the presence of segregation, pipe, or some other mechanical defect, to reject the rail represented by the test piece. Following such rejection, a test piece shall be cut from the bottom end of the same rail and broken; if that piece has similar defects, the second, or B, rail is rejected, and a piece cut from its lower end, and tested. In case of failure, the procedure is continued for the succeeding rails until a sound one has been reached. This has proved an expeditious and cheap procedure, and in my judgment very satisfactory.

A large tonnage of rails made under it is in American railway tracks and a much larger tonnage in those of Canadian railways. In fact, at the present time



every standard steel rail rolled in Canada, and for all of that country's roads, is so made.

As the chemical composition of the steel is a fundamental part of rail specifications, a very important point is the taking, for analysis, of the drillings representing the heats of steel from which the rails are rolled. The drillings must be taken from test ingots, and the time and manner of casting these ingots, as well as their shape, is receiving attention. In fact, the whole matter of ladle-test ingots is now receiving the attention and study of a committee of the American Society for Testing Materials in conjunction with the United States Bureau of Standards. Pending a full report on the subject by them, it would appear desirable to require the adoption of a standard sized and shaped ladle-test ingot and to insist that it be cast as sound as possible by the addition of aluminum to the molten steel; further, that two or three should be cast at equal intervals in a heat during the pouring of the large ingots and drillings from them carefully mixed. Thus, greater protection would be afforded as against a single small test ingot not representing, thoroughly, say, a 100-ton heat of steel.

All specifications should demand that the inspector representing the purchaser should have the right to witness the taking and mixing of the drillings, from which mixture, upon his request, he is given a portion for the purpose of check analysis. As a rule this is done, but at some plants it is a subject of dispute, which should be prevented.

Much thought and considerable experiment have been given to the betterment of the cold straightening of rails. From the time of that procedure being represented by the blows of a heavy sledge swung by a sturdy man, the practice has been a brutal one. To accomplish the semblance of the desired result, the steel has to be bent beyond its elastic limit, thus establishing strains with an ever present danger of causing actual or incipient ruptures in the metal, which may result in complete rail failures. In my judgment, it is practical to do away with cold straightening, by proper hot straightening of the rails. If, in case of uncontrollable conditions, a few rails should come from the hotbeds unsuitable for use, they could, after some cold straightening, be classed as seconds and used for other than main-track purposes.

In the present practice, a rail is put under the cold press and most carefully, but brutally, punched into seeming straight line and surface. Frequently, it is later put on the ties and with equal care spiked out of a straight line into curves of varying degrees. Rails can be hot straightened without any short kinks and with lines that will permit good loading for transportation and satisfactory track laying; thus can the expense and danger of the cold straightening be avoided. There are now at least 1,000 tons of rails, finished as above advocated, giving satisfactory service in the lines of several railroads having heavy traffic, and they have had over three years of trial. The rail makers will welcome such a departure from present practice and, I am confident, make it successful.

To secure sound rails it is of supreme importance to make sound ingots. Sir Robert Hadfield, in Octo-

ber, 1912, presented a paper before the Iron and Steel Institute\* which attracted wide attention and much discussion. The plan is broadly designated as using a "hot-top ingot," and many plans of obtaining such castings, other than directly following Sir Robert's, have been and are being successfully employed, notably, on ingots to be used in ordnance work. As yet hot-top ingots are not used in rail making; both encouraging and disappointing experiments have been made, but I am satisfied that it is practical and will be so proved. Based on the results obtained with other than rail ingots, its success with them is bound to come. Therefore, while I am not at this time prepared to incorporate hot-top ingots in rail specifications, the time is near when it will be entirely practical to do so. It may involve a somewhat greater first cost, to be at least partly offset by saving in scrap, but if the outlay is justified when making steel to be used in destroying life, should it not be even more so when producing metal on the soundness of which human safety will so largely depend?

The threatened shortage of high-grade manganiferous ores during the late war years led to economy in the use of metallic manganese, particularly through the more general adoption of the practice of adding it to the charges in a melted condition. The obtained results from a metallurgical point of view have been very satisfactory and specifications should insist on the practice.

The importance of the chemical composition of rail steel cannot be gainsaid. In former times, when acid Bessemer steel was used for rails, its composition was restricted to a large extent by the character of the original ores, it was controlled with considerable ease by the condition of the process itself. Heat after heat of fairly uniform composition was produced and, in short, the desired aim for the various ingredients of the steel was readily obtained. But basic open hearth steel manufacture is fraught with far more difficulty, for, while the initial composition of the charge does not exert so much influence, the attainment of the desired composition for the heat is dependent on so many constantly varying conditions that a wider latitude in the range for some of the different elements must be provided. The time will come when this will not be necessary and the practice of using molten additions for recarburizing enables operations on a much more consistent basis with respect to furnishing steel of the analysis desired.

The most harmful physical characteristic of rail steel is, of course, brittleness. The low amount of phosphorus present in open hearth steel renders protection against the dangers from that element and permits freer use of carbon as a hardening element. Experience has pretty well demonstrated that the safe upper limit for carbon in rail steel is approximately 0.75 per cent; and accepted practice has allowed a working range of 13 points, with the result that the lower limit of carbon has been most frequently specified as 0.59 per cent., but in some cases 0.62 or 0.63 per cent; speaking, of course, of the almost universally

\* Journal Iron and Steel Institute (1912) 86, 11.

(Continued on page 525)



## Industrial Uses of Superheated Steam

**Superheating in an Engine Saves by Reducing Condensation and Radiation Losses—Tests Made by U. S. Steel Corporation on Blowing Engines Indicates Average Saving of 13.33 Per Cent.**

By ALEXANDER BRADLEY.

In 1705 Denys Papin, the French physicist, made what was probably the first application of superheated steam. By placing a mass of heated metal in a recess of the piston, on the steam side of Dr. Savery's engine, or pump, he reduced the condensation of the working steam and produced what was in effect a superheater. A certain Capt. MacGregor in Cornwall, England, in 1828, built a brick jacket around the cylinder and the steam pipe of his pumping engine; he left a space or

ing, condensing, improved valve gears and last but not least higher steam pressures. These improvements together with the troubles encountered in stuffing boxes, gaskets and lubrication on superheated steam, tended to limit its use for a number of years. In 1874 Dr. Kirk introduced the triple expansion engine and it soon became the standard type of marine engine. The steam pressure was still further increased and consequently the temperature thus militating against superheating under the then existing conditions.

Hirn continued his experiments and in 1892 in a series of tests showed a saving in fuel of 20 per cent with the superheater installed within the boiler setting. He superheated the steam to from 86 to 113

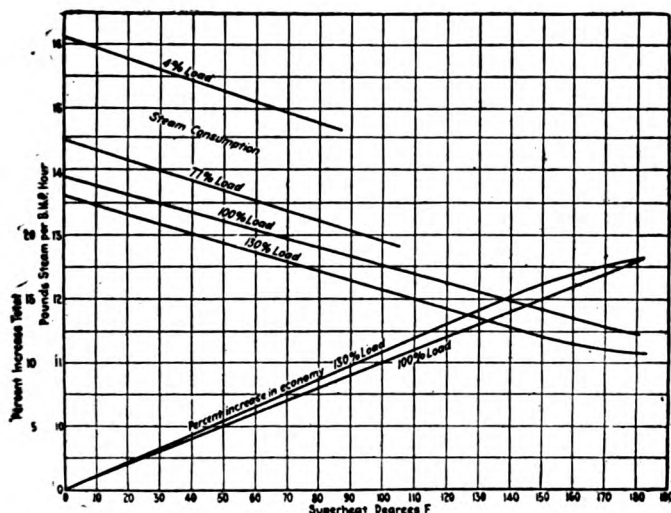


Fig. 1—Relations of superheat to economy for a 400 kw Westinghouse Parsons turbine.

flue between the brick and the metal and by maintaining a fire in this space he reduced the steam consumption of his engine to a remarkable extent.

Up until about 1870 engineers took great interest in superheated steam. Ericson, Hirn and Isherwood conducted many experiments, securing excellent results. During this period most of the superheaters were installed in connection with marine boilers.

However, about this time vast improvements in the steam engine were introduced, namely, compound-

From paper presented by author before Pittsburgh meeting of the American Society of Heating and Ventilating Engineers.

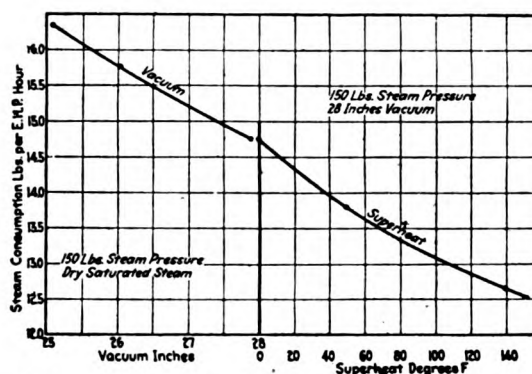


Fig. 2—Effect of vacuum and superheat on steam consumption of a 1,500 kw turbine at full load.

degrees F. His successors, Schwoerer, Schroter and Schmidt made rapid strides in again bringing superheating into use. In 1895 Schmidt built a boiler and engine for use with superheated steam and Prof. Schroter's tests showed that it developed an indicated horsepower upon 10.4 lbs. of steam per hour, or about 1.3 lbs. of coal. The steam pressure was 156 lbs. and the superheat 189 degrees.

This was a remarkable performance, especially as the engine was of only 75 hp. Soon after the reports of this and other tests were published, interest in superheating rapidly revived, especially in Europe. Lubricating oils, packings and gaskets were brought

out which gave perfect satisfaction on superheated steam. During the last 10 years pressures have been steadily increasing, as has also the amount of superheating, resulting in higher final temperatures.

At about 600 degrees F. cast iron fittings and valves when used on superheated steam at the present high pressures, are apt to "grow" or expand, and then take a permanent set. At somewhat higher temperatures, the cast iron commences to lose its strength and becomes in time unable to withstand the pressure. Much apparently conflicting evidence has been submitted upon this subject. After an experience of 15 years with superheaters and superheating, the truth appears to be that cast iron fittings and valves give good service on superheated steam at 500 to 550 degrees F. if built in the first place of good gray iron and of the proper strength to carry the pressure. If, however, a superheater is employed which gives wide fluctuations in the degree of superheat, the cast iron will "grow" and become "fatigued" in time.

There are many plants which have been in operation for 10 years or so, where the cast iron fittings and valves are still giving good service, and that with pressures, up to 175 pounds and superheating up to a final temperature of 525 to 550 degrees F. Up until

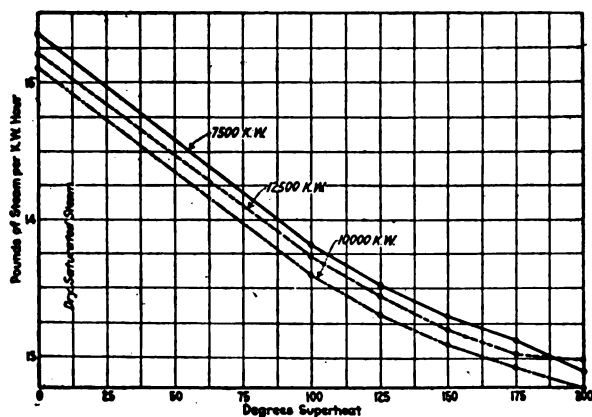


Fig. 3—Effect of superheated steam in reduction of steam consumption of 12,500 kw Westinghouse turbine.

the last few years, cast iron has been the only metal used for this purpose in Europe, where they employ higher pressures and higher superheat than we do in this country, though it should be stated that they claim to be able to produce a much better grade of cast iron than is made here.

Steam at any given pressure, is said to be saturated so long as it remains in contact with the water from which it is evaporated. If it is now separated from the water and more heat added to it, its temperature increases, it becomes practically a perfect gas and is said to be superheated.

The specific heat of superheated steam, that is the heat required to raise 1 pound 1 degree varies with the pressure and also with the temperature; it increases with the pressure but decreases as the temperature becomes higher. At 50 pounds absolute pressure, the specific heat is 0.498 for 100 degrees superheat, and 0.491 for 200 degrees superheat; while at 250 pound absolute pressure it is 0.615 for 100 de-

grees superheat, and 0.562 for 200 degrees superheat.

Being practically a perfect gas, superheated steam follows the laws of gases, its volume increasing with the increase in temperature, and in direct proportion to the absolute temperature. As an example of this characteristic, saturated steam of 150 pounds pressure and an absolute temperature of 826 degrees has a volume of 2.75 cubic feet per pound. If this steam is superheated 100 degrees the absolute temperature increases to 926 degrees while the volume increases to 3.08 cubic feet, an increase in volume of 12 per cent. The heat added has been that amount which is necessary to raise the temperature 100 degrees, and as the specific heat of superheated steam at 150 pounds pressure and 100 degrees superheat is 0.566, this amount is 56.6 Btu. The total heat of saturated steam at 150 pounds pressure is 1,227 Btu above zero, hence the 12 per cent increase in volume has been obtained by increasing the total heat by only 4.6 per cent.

Steam at any pressure can be superheated, and so long as it remains in connection with the source of supply of saturated steam, the pressure will not in-

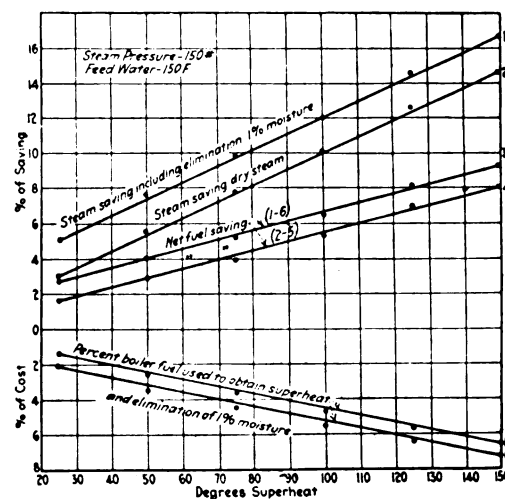


Fig. 4—Diagram showing steam and fuel savings due to superheat in steam turbines.

crease. As this is the usual operating condition it may be stated that superheating steam does not increase its pressure.

The following example will serve to show how superheating reduces the steam consumption of an engine. In a certain engine (Schmidt) it was found that for each 1 per cent of wetness, or steam condensed at the point of cut-off, when using saturated steam, it required 7.5 degrees superheat in the entering steam to prevent condensation up to that point. Thus, in case 25 per cent of the saturated steam condensed at cutoff, there would be required  $7.5 \times 25 = 187.5$  degrees of superheat in order for it to be dry at that stage.

Suppose then it takes a pound of steam to fill this cylinder at cutoff, which would require for its production 1,000 Btu; in the first case 25 per cent condensation took place, a total of  $1 \frac{1}{3}$  pounds was admitted, to produce which takes 1,333 Btu; in the second case in addition to the 1,000 Btu to produce



the steam sufficient heat must be added to superheat it 187.5 degrees and taking the specific heat at 0.48, 90 Btu additional are required.

Since the work performed can be said to be the same in both cases, the heat required is 1,333 Btu in the first case and 1,090 Btu in the second, or a saving of 23.3 per cent of the steam by superheating. Thus in an engine, superheating saves by reducing condensation of the steam and loss by radiation through the cylinder walls. On turbines superheated steam shows a decided saving, reduces the wear of the blading to a minimum, and increases the capacity in horsepower.

Fig. 1 gives the relation of superheat to economy on a 400 kw Westinghouse turbine. Fig. 2 is interesting in that it shows the saving made in a turbine by a vacuum up to 28 in. and by superheating up to 150 degrees.

In both engines and turbines, however, the guarantees of the builders and the basis of comparisons are upon dry saturated steam upon one hand and super-

degrees superheat would add at least 4 per cent in the saving shown between dry saturated steam and 100 degrees superheat on this chart. It will be noted that after about 100 degrees of superheat have been reached the curves tend to ease off slightly, which bears out actual practice, that is to say, the greatest saving accomplished by the elimination of the water and superheating 100 degrees.

Fig. 4 shows some curves worked out to illustrate the saving in both steam and fuel by superheating, when the saturated steam is dry as well as when it carries 1 per cent water.

Experience with several hundred engines of the Corliss and slide valve types indicates that with steam pressure up to 200 pounds it is practical and very beneficial to superheat the steam up to a final temperature of 475 to 500 degrees F., which generally means that there will be a temperature in the steam at the throttle of the engine of from 450 to 475 degrees. Piston valve and poppet valve engines admit of carrying the superheat much higher and with good economy, although it is generally found that the first 75 to 100 degrees of superheat effects a greater economy than any succeeding like amount.

In a general way it may be stated that the saving in steam and in fuel by using superheated steam on reciprocating engines, pumps and compressors, is as follows; assuming 100 degrees superheat as an amount most frequently used:

|                                       | Steam saving per cent | Fuel saving per cent |
|---------------------------------------|-----------------------|----------------------|
| Simple engines and compressors.....   | 18                    | 13.5                 |
| Compound engines and compressors..... | 14                    | 10.5                 |
| Triple engines and compressors.....   | 12                    | 9                    |
| Simple direct acting pumps .....      | 22                    | 16.5                 |
| Compound direct acting pumps.....     | 18                    | 13.5                 |
| Triple direct acting pumps .....      | 16                    | 12                   |

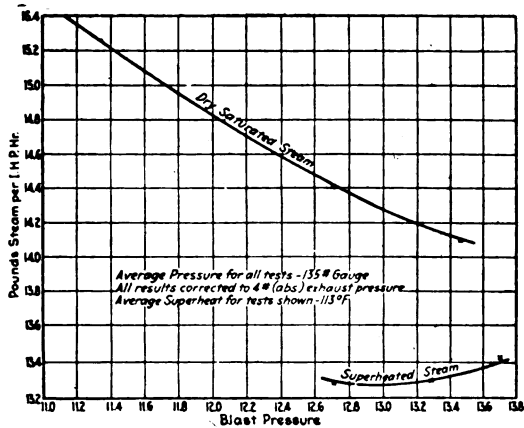


Fig. 5—Comparative test by United States Steel Corporation on steam consumption of Allis-Chalmers cross compound engine.

heated steam upon the other. As a matter of fact saturated steam always carries water in actual practice; generally it is found to be what is termed commercially dry and contains about 2 per cent of water. For each 1 per cent of water the builder demands a correction in his saturated steam consumption of 2 per cent. Any reputable builder of turbines or engines will today guarantee 10 per cent of steam saving if given 100 degrees of superheat as compared with dry saturated steam. Therefore, as there are in practice 2 per cent water, 4 per cent are gained by eliminating the water which, plus 10 per cent equals 14 per cent, the actual steam saving with 100 degrees superheat as compared with every day saturated steam.

Fig. 3 illustrates quite clearly the reduction in steam consumption by using superheat in a 12,500 kw Westinghouse turbine at 200 pounds steam pressure and 28 in. of vacuum. It should be noted that the saturated steam points are on the dry saturated steam line. Back of this line where there would be moisture in the steam, the curves would ascend quite abruptly so that the difference in steam consumption per kw hour between saturated steam with say 2 per cent of water and superheated steam with say 100

A few years ago a comparative test was run by the engineers of the United States Steel Corporation at one of its plants in order to ascertain what saving could be made in the steam consumption of a large Allis-Chalmers cross compound blowing engine. Fig 5 gives the results obtained, in the form of two curves, the upper curve showing the consumption on saturated steam, while the lower curve shows the consumption on superheated steam. These give an average saving of 13.33 per cent with 113 degrees superheat, and this too upon a very economical engine. There were several different types of engines tested and the entire series were very well conducted and the results most interesting.

It should be borne in mind that the total saving is not made in the prime movers, to be mostly offset by the cost of additional fuel required to obtain the superheat. A properly designed superheater attached within the setting of a boiler always results in at least as good an efficiency for the combined boiler and superheater as for the boiler alone; generally the combined efficiency is higher and often to such an extent that the first 50 degrees of superheat are obtained without the expenditure of any additional fuel.

Being a perfect gas, as long as any superheat remains, superheated steam can be put through pipes at a higher velocity than is permissible with saturated

steam at the same pressure. This means smaller piping, resulting in reducing the cost of the items of piping valves and fittings and covering. The loss in pressure through a long line is considerably less when the steam is superheated than when it is saturated, some existing lines having been improved in this respect by as much as 50 per cent.

During the last few years a number of interesting uses for superheated steam have been developed. The Peoples Gas Light & Coke Co., of Chicago, is blowing its water gas generators with superheated exhaust steam at about 2.5 pounds pressure, instead of using live steam as has been the standard practice heretofore. The saving in boiler fuel averages 20 per cent and there is at the same time a very satisfactory increase in the capacity of the gas generators themselves. The increase in capacity of the generators is due to the fact that the blowing period is prolonged fully one minute, thus demonstrating the great value of dry and superheated steam, as it relieves the generator of the work of re-evaporating water which always is present in the saturated steam at the generator.

Under the general heading of the use of superheated steam in process work, a line can be fairly well drawn on one side of which the operations can be successfully performed with superheated steam (and by successfully is meant that they are commercially practicable) and on the other side of the line superheated steam will either not function satisfactorily, or if it does, the cost of the operation is prohibitive. Where both the latent heat and the superheat of the steam can be utilized the operation is always successful and the use of superheated steam eminently practicable. Thus, wherever, the steam can be blown directly into the mass to be heated, whether the latter is in powder form, paste form or liquid form, the effect desired is obtained and practically the only heat lost in that due to radiation.

If the superheated steam is tried in a jacketed kettle or in a closed coil where the condensation is taken off by means of a trap or vacuum system, the results will be found to be disappointing, and this is because when the steam is superheated its specific heat is lowered practically one-half, its volume is in-

creased and it is a gas. This means that not so many pounds of it can occupy the jacket or coil, that none of the latent heat can be given up until all the superheat has been absorbed. This superheat only gives  $\frac{1}{2}$  Btu for every degree of reduction in temperature, therefore very little heat is given up by the superheat in the steam, although what heat is given up is at a high temperature. The latent heat is then available and it is this that does practically all the work, but this latent heat has not a sufficiently high temperature to produce the desired heating effect and the small number of heat units at high temperature given up by the superheat in the steam has not been enough to measurably increase the average temperature of the mass to be heated. It will be seen that these heating operations are a function of heat and also of temperature. There is a way in which the desired effect can be obtained by using superheated steam, namely by using a coil or coils with one pipe to carry the steam and of sufficient length, so that when blowing the steam directly through at a very good velocity there is sufficient heating surface to transfer practically all of the superheat to the mass to be heated and allowing the steam with all its latent heat still remaining, to blow straight through. It will be seen that we are in this case utilizing the steam as a means of conveying the superheat and that we will require a great many pounds of steam in order to do this. It is of course impractical in most instances, because of the amount of steam required and the great cost of fuel consequent upon the total loss of the latent heat.

In some cases the saturated steam leaving the coil can be put through an engine or pump or into some other process requiring lower temperatures and thus use can be made of the saturated steam: in such a case the process can many times be made economical and satisfactory. There are one or two other ways in which the superheat only can be used in one operation and the latent heat, or a portion of it, in another and connection operating. These operations must be so related in their demands for heat that the saturated steam left from the superheat operation will be sufficient to produce the desired result in the second operation.

## Condenser Installations in Steel Mills

**Increased Attention to Economy in Steel Mill Power Plants  
and Use of Turbo-Generating Units Indicates Adaptability  
of the Low Level Jet Condenser.**

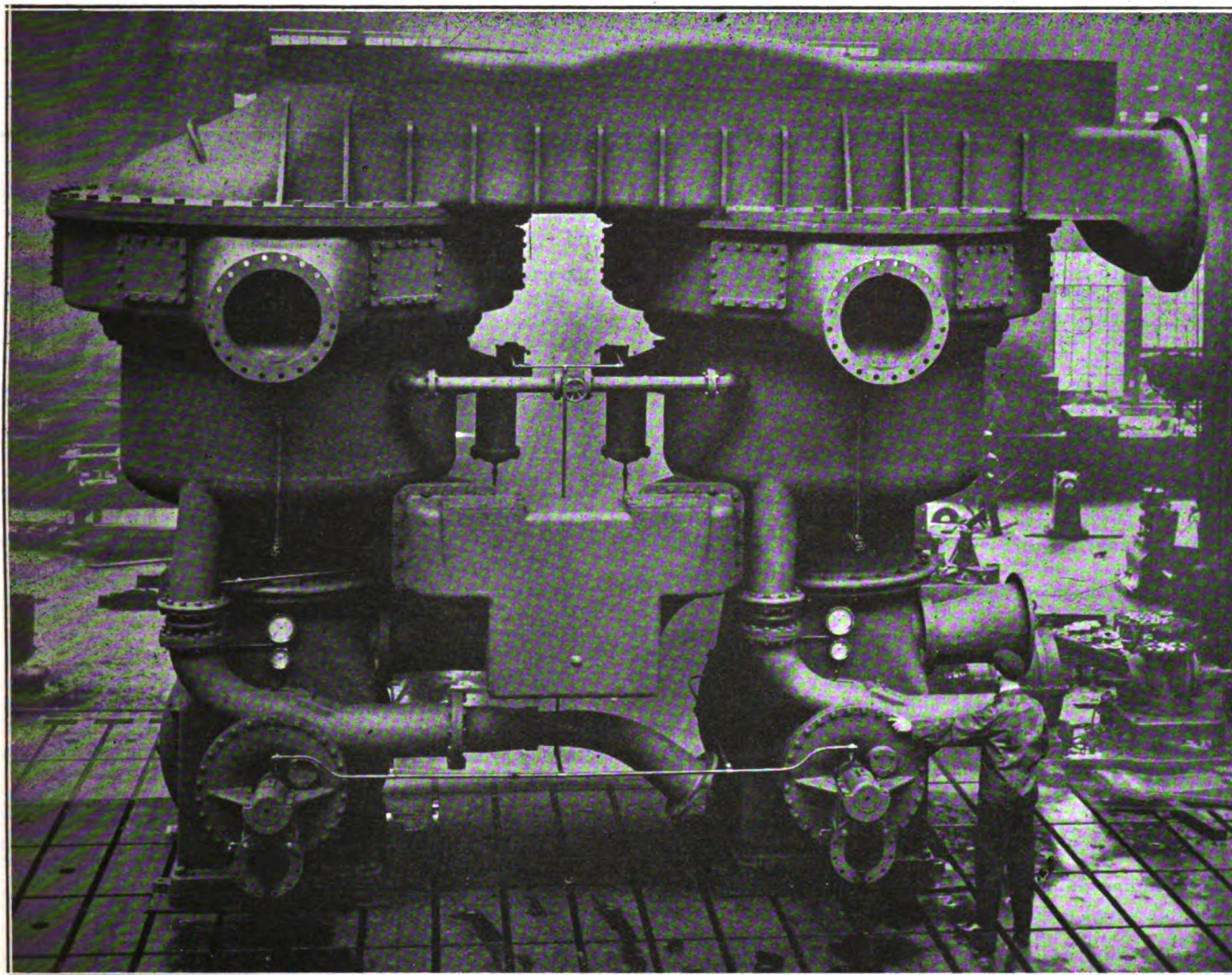
By F. A. BURG,  
Westinghouse Electric & Manufacturing Co.

In the production of steel, the greatest attention has been paid to refinements in manipulation of the product of direct sale rather than to improvements in the power producing machinery required to drive the rolls and various machines throughout the steel mill. The production of power in steel mills in the past has been of secondary consideration, and consequently in line with other steel mill equipment the power plant equipment has been selected for ruggedness and serviceability rather than any

refinement of design and consequent overall economy.

Hence, in the matter of condensers we would naturally expect to find that type of condenser which early demonstrated its reliability unless water conditions absolutely demand the installation of a surface type. This is the barometric condenser, or high level jet condenser, in which the condensing head is placed at such an elevation above the discharge water level that after the condensing water has been introduced to the condenser the discharge



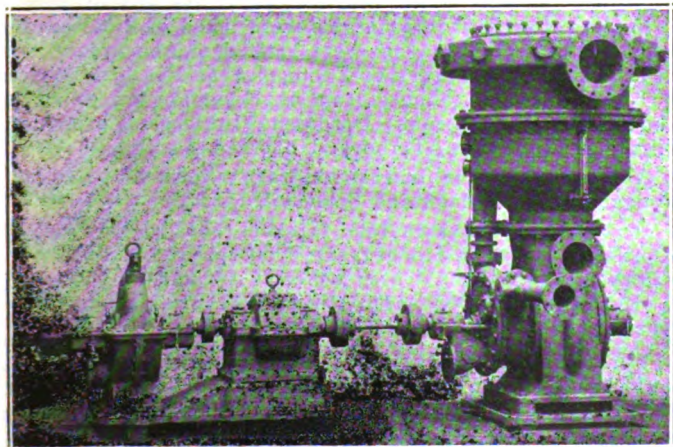


Westinghouse large twin jet condenser.

will flow away by gravity, no discharge pump being required. It is true that quite frequently water has to be pumped up to the condenser head and the condenser placed so far from the prime mover that the drop in vacuum in the exhaust pipe is excessive, however, the dependability of this condenser has contributed to its popularity with steel mills.

There are very few operating conditions where the

barometric condenser makes an ideal installation. The factors contributing to such an installation are, a plentiful supply of water within the suction limit of the condenser, and the contour of the property such that the condenser head can be placed beneath or very near to the exhaust nozzle of the prime mover and still have the required drop for gravity discharge of the condensing water.



Small turbine and gear driven jet condenser.

The low level jet condenser has proven itself to be a high vacuum machine and is very dependable in operation. Consequently mill installations are being made where low level jet condensers are used in order to put the condenser directly beneath the turbine and eliminate the drop in pressure in the exhaust pipe. For the average installation there is not a great deal of difference in the power required to drive the pumps of a low level jet condenser and a barometric condenser if the water has to be pumped up to the barometric condenser water inlet. For this reason the advantage of being able to produce the high vacuum at the place where it is needed as well as compactness and elimination of an expensive exhaust pipe have proven to be deciding factors in the low level jet condenser installation, consequently we find an increasing number of low level jet condenser installations in steel mills.



## FOREIGN RELATIONS

### MARKET FOR IRON AND STEEL IN NETHERLANDS.

(Trade Commissioner Arthur H. Redfield, The Hague.)

The Netherlands possesses no deposits of iron. For the simplest forms of iron and steel the country is entirely dependent on importation. The Dutch foundries operate on scrap and old iron, of which a good share is normally imported. Even the blast furnaces to be erected at IJmuiden will depend on imported Swedish or Spanish ore for their raw material. In the more elaborated forms, also, the main dependence is on importation.

The present iron and steel situation is one of accumulated shortage. Imports of unmanufactured and semi-manufactured forms of iron and steel totaled 2,019,288 metric tons in 1913, the last normal pre-war year. These dropped to 1,411,904 tons in 1914, 758,232 tons in 1915, 500,378 tons (calculated) in 1916, 159,970 tons in 1917, and to 164,911 tons in 1918. With the domestic iron and steel industry inadequate to fill at any time the national requirements, it is evident that a strong demand exists today.

Two-thirds and more of these imports have come from Germany, with Belgium and Great Britain occupying a subordinate place. The share of the United States in this trade has been at all times insignificant.

The value of the Dutch imports of unmanufactured and semi-manufactured iron and steel was \$199,523,421 in 1913, \$112,431,061 in 1914, \$40,760,300 in 1915, \$22,252,871 in 1917, and \$35,481,768 in 1918. While the values down to 1915 are based on arbitrary official standards they form a basis for estimating the financial importance of this trade.

#### Germany Leading Source of Dutch Iron and Steel Imports.

Unmanufactured iron in blocks and bars was imported for consumption to the amount of 325,025 metric tons in 1913, 208,562 tons in 1914, 46,676 tons in 1915, 57,735 tons in 1916, 32,942 tons in 1917, and 25,367 tons in 1918. Germany supplied 42.5 per cent of this in 1913, Great Britain 40.7 per cent, Sweden 9 per cent, and Belgium 5.4 per cent. In 1918 Germany furnished 51.5 per cent and Sweden 48.2 per cent.

Imports of iron rods, bands, and plates amounted to 785,896 metric tons in 1913, 636,197 tons in 1914, 525,361 tons in 1915, 346,263 tons in 1916, 88,991 tons in 1917, and 95,836 tons in 1918. Of these imports in 1913, 88.3 per cent came from Germany, 7.4 per cent from Belgium, and 3.4 per cent from Great Britain. In 1918 Germany again led with 89 per cent, followed by Sweden with 8.4 per cent, and Belgium with 2 per cent.

Iron rails were imported to the extent of 39,975 metric tons in 1918, 49,286 tons in 1914, 26,255 tons in 1915, 14,769 tons in 1916, 1,765 tons in 1917, and 1,877 tons in 1918. Germany was the source of 95.5 per cent of the Dutch imports of rails in 1913, and in 1918 that country supplied 88.9 per cent and Sweden 9.9 per cent.

Gas and water pipes were imported to the amount of 59,563 metric tons in 1913, 39,158 tons in 1914, 32,855 tons in 1915, 36,454 tons in 1916, 8,416 tons in 1917, and 11,913 tons in 1918. Of the 1913 imports 65.2 per cent came from Germany and 18.7 per cent from Belgium. Germany furnished 94.5 per cent of the imports in 1918 and Sweden 4.2 per cent.

Sheets and plates were purchased to the value of \$10,969,066 in 1913, \$8,901,327 in 1914, and \$7,313,907 in 1915; later figures are not available. The values quoted, moreover, are arbitrary official appraisals for customs purposes and do not necessarily represent actual value. Germany supplied 66.2 per cent of these purchases in 1913.

Of the \$239,481 worth of ship's anchors and chains imported in 1913, Great Britain supplied 75 per cent and Germany 19.9 per cent. In 1917 imports of anchors and chains equaled 167

metric tons, and in 1918 equaled 211 metric tons, of which Germany supplied 23.3 per cent, Great Britain 20.8 per cent, and Norway 16.5 per cent.

#### Imports of Nails, Wire, Steel Sheets, Rails, Tools, etc.

The Netherlands imported 31,264 metric tons of nails and spikes in 1913, 23,163 tons in 1914, 16,077 tons in 1915, 12,037 tons in 1916, 2,734 tons in 1917, and 2,469 tons in 1918. Germany was the origin of 75.2 per cent of the 1913 imports, and the United States of 9.7 per cent, Belgium of 8 per cent, and Great Britain of 5.9 per cent. In 1918 Sweden furnished 33.8 per cent of the imports, Denmark 28.2 per cent, Germany 24.9 per cent, Norway 5.8 per cent, Great Britain 3.8 per cent, and Belgium 3.4 per cent.

Iron wire was imported to the amount of 259,603 metric tons in 1913, 66,177 tons in 1914, and 19,562 tons in 1915. Later figures are not available. Germany furnished 95.2 per cent in 1913 and Belgium 4.2 per cent.

Imports of iron cable work totaled 2,096 metric tons in 1913, 1,602 tons in 1914, and 1,013 tons in 1915. Great Britain supplied 65 per cent of these imports in 1913 and Germany 32 per cent.

Old iron and scrap for the Dutch foundries was imported to the amount of 112,906 metric tons in 1913, 80,809 tons in 1914, and 6,856 tons in 1915. Great Britain furnished 57.2 per cent of this in 1913, Belgium 19.1 per cent, and Germany 5.6 per cent.

The Netherlands imported 234,958 metric tons of steel sheets, plates, and bars in 1913, 166,878 tons in 1914, 33,257 tons in 1915, and 33,120 tons in 1916. No later figures are obtainable. Germany supplied 66.5 per cent of the 1913 imports, Belgium 28.9 per cent, Great Britain 2.6 per cent, and Sweden 1.6 per cent.

Steel rails were purchased from abroad to the extent of 151,885 metric tons in 1913, 134,354 tons in 1914, and 29,900 tons in 1915. Later figures are not available. In 1913 Germany provided 79.4 per cent of these rails and Belgium 20.5 per cent.

The value of the tools imported into the Netherlands was arbitrarily appraised at \$984,536 in 1913, \$799,571 in 1914, and \$675,057 in 1915. Of the imports in 1913, 62.5 per cent were of German origin, 23.7 per cent of British origin, and 9.9 per cent of Belgian.

Dutch imports of steel wire amounted to 7,176 metric tons in 1913, 3,346 tons in 1914, and 1,049 tons in 1915. Germany furnished 73.6 per cent of the steel wire imported in 1913, Great Britain 12.6 per cent, and Belgium 12.1 per cent.

#### Domestic Manufacture of Iron and Steel.

No less than 88 iron foundries were listed in the Netherlands in 1918. Of these, six were located at Amsterdam, six at Telegen, six at Bergen-op-Zoom, five at Enschede, three at Breda, three at Tilburg, two at Hengelo, two each at Almelo, Blerick, Deventer, Dordrecht, Jutphaas, Maastricht, Nijmegen, Rotterdam, Terborg, Ulft, and Zwolle.

Anchors are cast in four establishments, located at Leyden, Hoogezand, Rotterdam, and Schiedam.

Iron wire is drawn in four factories, located at Amsterdam, Delft, Haarlem, Hoogezand. Iron cable is made by one factory at Rotterdam. Three factories, located, respectively, at Bloemendaal, Deil, and Rotterdam, manufacture iron gauze.

Wire nails are manufactured by 14 establishments in the Netherlands. Four of these are located at Helmond, two at Beek en Donk, and the others at Baarn, Eindhoven, Haarlem, Maastricht, Schiedam, Elikerveer, Tilburg, and Utrecht. Blunt nails are made in two factories at Apeldoorn and at Maastricht.

## PRODUCTION TOPICS

### REDUCING LOSS IN STEEL RAIL MANUFACTURE

(Continued from page 578.)

accepted practice of having the steel contain not over 0.04 per cent phosphorus. The problem of always making basic open hearth steel within this range is difficult and frequently heats are cast slightly outside the limits specified. There is a much greater commercial opportunity for manufacturers to find other than rail uses for steel containing the lower amounts of carbon than when containing the higher amounts; therefore, they naturally aim to have the carbon content nearer the low side of the permitted range. Hence, the larger percentage of heats is on the low side of the allowed carbon. In repeated cases, "off heats" are produced which fail to be within the prescribed limits of the particular specification to which the rails are being rolled, but are entirely applicable to another rail specification for which the mill has orders. This leads to the ingots from such heats being temporarily discarded, later to be reheated and rolled on the other specification. This means reheating and rolling of cold ingots, which is invariably accompanied by an increased production of second-quality rails, largely augmented by the lack of proper control and treatment in the soaking pits.

The various railway systems of the country are now using as their standard practice about the same weight of rails. There are some variations of sections, but I do not see any serious objection to the adoption of a general or common chemical specification. We know that hundredths of percentages are very delicate variations and, especially in relation to carbon, errors may occur in the results obtained by two different chemists, particularly if working under modern manufacturing pressure. If a common carbon, silicon, manganese, and phosphorus specification prevailed, the work of the open hearth steel melter would be simplified, the cold-ingot trouble eliminated, and, I think, better general results obtained.

### WEIRTON BLOWS IN NEW BLAST FURNACE.

(Continued from page 516.)

plus and escapes to the sewer at the present, but with the starting of the steel plant, provision is made to use 1,500 gallons a minute of this water.

The reserve capacity in the cistern is 225,000 gallons, sufficient to run the furnace and boilers alone for several hours. The bottom of the pump suction line on the condenser pump pulling from the cistern, is high so that in the event of a shortage of water, the blowing engine condenser pump will draw air very early and cause the engine to drop its vacuum and go on atmosphere, thus conserving cistern water for furnace use. The bottom of the suction lines on the service and auxiliary service pumps from the cistern is at the maximum depth. There are three of the 3,200 gallons service water pumps in the basement, two of which are in continuous operation, one pumping to the furnace and drawing 95 degrees water from the cistern and one pumping 115 degrees water to miscellaneous uses from the weir from the blower condenser. Suctions on all three pumps are cross-connected to both sources of supply, and discharge on all three pumps is cross-connected to two lines leading to the furnace. These lines are laid out for extension to the south for the future furnace, and room is left in the pump basement for installation of three duplicates of existing pumps for the Nos. 2 and 3 furnaces, for the additional condenser pumps, for the further installations of

blowing engine condensers and for the recirculating pumps to deliver excess 115 degree water to the steel works. The river pumps are Allis-Chalmers with Allis-Chalmers motor drive. The power house pumps are all Alberger, two of the service pumps having Alberger-Curtis turbine drive and the spare service and the blowing engine condenser pump having Allis-Chalmers motor drive. A Knowles compound duplex pump is provided in the pump basement for emergency and casual high pressure requirements. Other safety provisions are automatic valves from the river water line to the cistern to keep water level at the point of weir overflow. These valves are supplemented by a direct connection with hand operated gate valve. There is also a by-pass connection from the river water line to the Alberger condenser weir. There is also an emergency 18" line from an independent supplied main from the tin mill pumps. This 18" line delivers to the cistern in case of emergency. This re-use of water not only reduced the actual pumping capacity by 55 per cent with economy in size of main, but enabled use to be made of a duplex system of water mains to the furnace, which would have been required in any event, as would have been the three service pumps.

The main sub-contractors on the work were the Jack Walsh Construction Company, who had charge of excavations, foundations and fill, including the bins, also all brick laying and who in addition installed the sewers and the 30" water line from the river to the power house and erected the condensing and power house equipment; John Mohr & Sons fabricated and erected the plate work. The Lackawanna Bridge Company fabricated and erected the structural steel, including skip incline and cast house, boiler house and power house. Piping was installed by B. Floersheim & Co.

The plans and specifications for the complete plant and plant equipment were drawn up by the engineers, Freyn, Brassert & Co., of Chicago, who also had supervision of construction. The operating and engineering organization of the Weirton Steel Company (through its executive J. C. Williams and its chief engineer of construction, C. H. Hunt) co-operated with the engineers in all details of the planning of the work, in the purchase and delivery of materials, and in the pushing of work in the field. The work was expedited by the remarkably open winter, and on the other hand retarded by the work coming in on the last four months of the war and the following armistice period when delivery of equipment and materials was severally handicapped by priority orders, both at manufacturing plants and on the railways.

The contractors operated a complete gravel and sand washing plant as all of this material was obtained from company's gravel pit. Other contractors equipment comprised three dinkey locomotives, 25 eight foot side dump cars, three steam shovels, one central concrete mixing plant, one car concrete mixing plant. There were 70,000 cubic yards earth fill, 26,000 cubic yards concrete, 250 tons reinforcing steel, 1,200 tons structural steel, 1,700 tons steel plate and castings exclusive of machinery and boilers. 2,700 feet 30 foot water line, 2,000 feet seven foot sewer, 2,500,000 fire brick and common brick. One hundred and fifty-one main contracts were executed, and the corresponding equipment and material delivered and installed to comprise the completed plant. The aggregate of the work performed is the more remarkable if it be stated that the preparation of plans for the plant started less than four weeks before ground was broken. Owners, contractors and engineers are justly to be congratulated upon the successful completion of plans and construction program of such magnitude and of such requirements within the time limit of one year.

# INDUSTRIAL RELATIONS

## CO-OPERATION AND INDUSTRIAL PROGRESS.

CYRUS McCORMICK, JR.,

Works Manager, International Harvester Company, Chicago.

It is not the purpose of the present paper to analyze completely all of the various causes entering into the industrial unrest that has swept over the world as a result of the war. Many conferences have given their attention to this subject and have adopted findings differing not so much in essential features as in the details of the plans suggested to ameliorate existing conditions.

It has been suggested that the difficulties under which employers and employees are operating are due to the nervous tension resulting from the war; to the high cost of living; to the fear of unemployment; to insufficient wages; to desire to share in the profits of industry; to a revolt against the old order of things whatever that may have been, etc. Each critic has, however, been more or less in agreement that the war taught nations once and for all time that individual workmen must be regarded as human beings. They are, to be sure, an element in production just as is the management, but the time has gone by when human labor can be bought and sold as are machines, tools, or raw materials. This lesson has long ago been learned by the majority of American employers, among whom the more liberal have for years been taking every forward step suggested to bring about a humanizing of industry. The results of the war, however, have made radicals out of many conservatives until at the present time some of the older European nations have, in theory at least, gone ahead of the United States. The man, as opposed to the machine, has the power to think, and is endowed with a soul. He is at last seeking recognition of this fact.

In agreement with many critics of the present industrial situation, I believe that the most significant feature in labor conditions of the day is the expressed desire of labor to share in the management of business. This desire has taken on various forms in different parts of the world. In Russia we see it as Bolshevism, which is nothing more or less than a practical application of the doctrines put forth some years ago by the I. W. W. in this country. The Bolsheviks tell us that the entire product of labor belongs to labor, and therefore they do not wish to have anyone receive a share of industry who is not engaged in manual production. Without attempting to argue the economics of this situation I merely call attention to it as the most radical phase of this desire. The Russian wants not only a share in the management, but the entire management. It has also been said that 65 per cent of the strikes which have taken place in central Europe since the war are of purely syndicalist origin. In this country we have had demand after demand catalogued generally under the term of "better conditions." In England we have seen a complete disruption of industry from which has grown up the so-called Whitley plan and more recently, the ever widening clamor for nationalization of industry. The underlying significance of all these movements is the final realization that the relations of employers and employees must from now on be formed on something besides a cash basis. The workman is as interested as ever in his wages and in his hours, but he is asking for more. Sometimes the demands are not well understood even by those putting them forward. What the workman really wants is self-expression. They are asking the right to discuss and adjust matters affecting their own interests.

Many employers in this country, sensing this situation, are admitting the right of their employees to discuss in joint conference, matters affecting the mutual interests of capital and labor. This, of course, has involved a recognition of

the principle of collective bargaining. Economists of the older school tell us that collective bargaining is detrimental to the best interests of the employees and that any artificial interference with wages will result in an artificial attempt to regulate prices. They claim that values are regulated by economic laws. This, of course, is true to a certain extent, but on the other hand it can be argued that collective bargaining is an aid to humanity and that it allows other economic laws to operate which might otherwise be held in abeyance. Not many years ago the doctrine of "caveat emptor" ruled every economic transaction and the business world was permeated with the ethics of David Harum. Just as that doctrine has vanished, so now is vanishing the fear of collective bargaining, and we find ourselves not only admitting the right of workmen to participate in the determination of working conditions but also discussing how this right may be most surely exercised. The method finding most favor in this country can perhaps best be classified by simply calling it employee representation.

## Reasons for Adoption of Employee Representation.

Two of the main reasons why employers are seriously considering the adoption of employee representation, are:

1. Syndicalism has made such rapid strides in Eastern Europe that some men, not recognizing the fundamental solidarity of the American people are afraid that this country is about to deliver itself to Bolshevism; therefore they are seeking to head off this unrestrained development and to provide a saner method by which the legitimate desires of the workmen for self-expression may be granted without at the same time completely ruining our present industrial fabric. Men of this opinion argue that the laborer has a right to speak for himself, and wish to give him this right before he resorts to revolution to obtain by force what he may think is being withheld from him. They believe discussion in an open forum cannot but bring results and that through efficient coöperation capital and labor, working together, will avert any possible danger of anarchy.

2. There is a close parallel existing between the movement in favor of employee representation and the growth of democratic government. Europe in the eighteenth century considered Frederick the Great's government to be nearly ideal. Later thinkers have called his government a benevolent despotism. Frederick was an enlightened man who elaborated a theory of government whereby the monarch sincerely tried to do the best he could for his people but always with the end in view of solidifying and increasing his own personal power. He built them fine buildings, instituted systems of education, did everything in his power to keep his subjects happy, but all with the objects of furthering his own ambitions. Eighteenth century Germany was materially happy but individually it was not allowed to have a voice in the direction of its own affairs.

After all is said and done, the fundamental point in our industrial trend today is the representative direction of industry; all else is really detail. Profit sharing may come when it is ripe for it to do so. Governmental action or rearrangement of our program of consumption may make it possible for employees to be free of fear of unemployment. Education may raise the standard of working conditions to a real art. But if workmen are allowed self-government they and their employers together can work out these programs. If not, they will never enjoy them. If the step of accepting employee representation is now taken by the American industry as a whole, the future is secure. The working out of all details can be safely left to the joint deliberations of that active intelligence, which, common to both men and management, has placed American industry where it is.



## NEWS OF THE PLANTS

The Detroit Seamless Steel Tube Company, Detroit, Mich., has commenced the construction of its proposed new plant on a local site, recently acquired, aggregating about 60 acres. The plant will be constructed on the unit plan, with the first unit estimated to cost close to \$1,000,000 including machinery and equipment. This unit will comprise a main building, 350x700 feet, of brick and steel construction, to be divided into three bays for manufacturing operation. Each bay will be about 90x700 feet long, and 45 feet high; a two-story administration building and boiler plant will also be constructed. The plant has been designed for a total capacity of about 2,500 tons of seamless steel tubing a month, with size of material ranging from one-half inch to six inches diameter, and of No. 13 gauge material and heavier. Equipment will also be provided for the manufacture of cold-drawn seamless steel boiler tubing, mechanical tubing, and locomotive flues. Electric traveling cranes will be installed, with other kindred equipment to facilitate the handling of materials. C. A. Ross is consulting mechanical engineer on the project.

The Follansbee Brothers Company, Pittsburgh, Pa., is considering plans for the construction of a new open hearth steel plant near Steubenville, O. The proposed plant will consist of a complete open hearth steel works, with four 40-ton furnaces and 10 sheet mills. The new plant will be used as an extension to the company's present open hearth steel plant, sheet and tinplate mills at Follansbee, W. Va. The new site is about 12 miles from the Follansbee works.

The Jones & Laughlin Steel Company, Pittsburgh, Pa., has completed the construction of a new blast furnace at its works at Aliquippa, Pa. The new furnace, which has now been placed in operation, is of the same type as the other four blast furnaces at this works; it will have a daily capacity of about 550 tons of pig iron, which the company will use in its open-hearth steel plants. This company is now operating a total of 12 blast furnaces, the others being at Eliza, where a battery of six furnaces is installed, and one at Soho. The combined daily output of the furnaces is about 7,000 tons of pig iron.

The Onondaga Steel Company, Syracuse, N. Y., is planning for the construction of a number of additions to its plant for increased capacity. The structures will include a large addition to the present mill building and annealing plant, about 40x160 feet, and a number of smaller buildings. The company recently increased its capital from \$150,000 to \$1,000,000, for general expansion. Samuel S. Buckley, is president.

The Algoma Steel Company, Sault Ste. Marie, Ontario, Can., is planning for the construction of a number of large additions to its plant for increased capacity. The structures, with machinery and equipment, are estimated to cost about \$5,000,000, and will be devoted to the manufacture of structural steel shapes of various kinds. As a commencement to this extensive expansion program, the company has inaugurated construction work on an addition to its rail mill to cost in excess of \$200,000.

The Reading Iron Company, Reading, Pa., is arranging for the early operation of the plant of the George B. Lessig Company, Pottstown, Pa., recently acquired. The works are being remodeled and repaired, and will be provided with

modern facilities for the production of puddle bars. The plant comprises two puddle mills, with a total of 22 double furnaces, provided with waste heat boilers, and three two-high puddle mill trains and a 22 inch three-high three-stand rolling mill for nail plate work. The nail factory at the works has an installation of over 100 cut nail machines, and will be operated by the new owner for wire nail production. The plant also comprises machine shop, forge shop, carpenter shop, cooperage works, and other structures. The puddle bar output of the plant will be used by the Reading company in connection with the manufacture of iron pipe.

The Jenifer Iron Company, Jenifer, Ala., is now operating its local blast furnace, recently rebuilt, for the production of pig iron. The company has installed new machinery and washers at its iron mines, and has also inaugurated operations at its coal properties at Weller, Ala. The entire works were secured from the Central Alabama Coal & Iron Co. recently. W. A. Thomas is president.

The St. Louis Coke & Chemical Co., St. Louis, Mo., has arranged for the construction of a new coke and iron plant at Granite City, Ill. The blast furnace will be of 500-ton capacity, and will be used for the production of pig iron. The company will use a portion of the coke produced in the blast furnace, and the remainder, with byproducts, will be sold on the open market. A large part of the pig iron production at the plant will be used by the Granite City Steel Works, a subsidiary of the National Enameling & Stamping Co., St. Louis. George W. Niedringhaus, president of this latter company, is interested in the coke and chemical organization.

The Dayton Malleable Iron Company, Ironton, O., has commenced the construction of a new open hearth furnace at its plant, with initial capacity of about 15 tons. The company has recently completed a new core building, about 60x80 feet, for increased capacity.

The Weirton Steel Company, Weirton, W. Va., is planning for the immediate construction of seven new 100-ton open hearth furnaces at its local plant, to provide for increased operations in this department of the works. The company is also planning for the installation of considerable other equipment, including metal mixer, with auxiliary machinery, and a complete coal handling plant. Contracts for the equipment for these latter items have been awarded. The plant is now producing about 525 tons of iron per day, and it is expected to increase this to about 600 tons at an early date.

The Lancaster Steel Products Company, Lancaster, Pa., is planning for the immediate construction of a new bar mill for increased capacity. The building will be about 50x310 feet, with a wing 50x70 feet. The company is planning to increase the capacity of the plant in all departments by about 15,000 tons of steel per annum.

The Carnegie Steel Company, Pittsburgh, Pa., is planning for the immediate construction of a new 18-inch band mill at its works at McDonald, O. It is planned to have the new mill ready for operation in about three months. The contract for equipment has been awarded to the Youngstown Foundry & Machine Co., Youngstown, O., which has constructed all of the mills at this plant of the Carnegie Company.

## WITH THE EQUIPMENT MANUFACTURERS

### THE WELLMAN GEARED BUCKET.

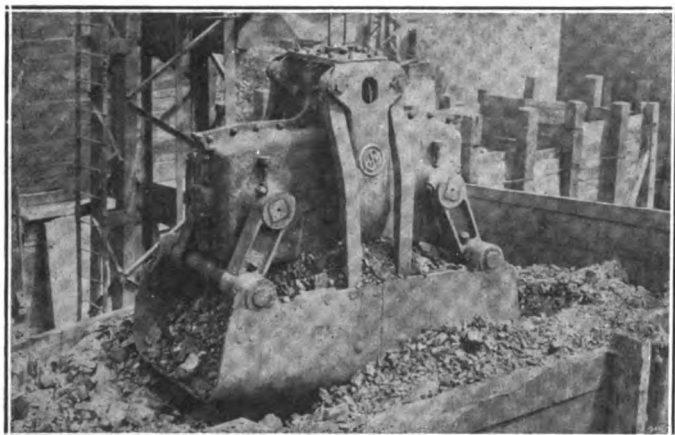
Throughout the entire field of handling bulk materials, such as coal, sand, gravel and cinders, the use of clamshell buckets has been attended by expense and serious delays necessitated by the renewal of operating cables or chains.

The ordinary construction of a clamshell bucket is such that a large quantity of the material handled comes in contact with the operating parts of the bucket. The inevitable result is excessive wear of those parts, due to the abrasive action of the material, and consequent delay and expense in removing and renewing the worn parts.

With the idea of eliminating these faults, the Wellman-Seaver-Morgan Company has developed a bucket, built in accordance with approved mechanical principles; possessing highly efficient digging qualities, minimum head room, and low center of gravity, combined with neat appearance and durability.

All of the working parts are completely enclosed in a tight casing where they are constantly lubricated and where they do not come in contact with the material the bucket is handling.

The bucket is composed of a minimum number of parts, so arranged as to facilitate the removal of any part in case of necessary repairs. It has no expensive chains or ropes reeved on small sheaves, no complicated parts or difficult adjustments.



This bucket is especially designed for handling coal, sand, gravel and cinders. It is operated by two ropes and, consequently, can be handled by practically any type of two drum hoist.

Departing from the usual design of grab buckets, which employ ropes or chains for their operation, this bucket has completely enclosed gearing to produce the necessary digging power.

The power casing, which forms the main frame of the bucket, and from which the shells are suspended, is divided in a vertical plane through its longitudinal center line. These two sections are bolted together to form two tight compartments enclosing the operating gears, and a third compartment in the center for the power wheel and the deflecting sheaves for the operating ropes.

The power wheel center is integral with the two bevel pinions which extend into the gear compartments and mesh with the operating segments. These segments are keyed to the operating shafts which are supported in bearings cast in the casing. The outer end of the operating shafts are finished square and support the rear bucket arms which in turn are connected to the shell shafts.

### NEW C-H SAFETY FIRST MOTOR STARTERS.

Unskilled labor, and the accumulation of dust, are two factors that must be considered in choosing the electrical equipment for smelters, foundries and other industrial plants. Motor starters of the enclosed type with simple operating

features are particularly desirable in the iron and steel industries. Two new starters, embodying these features are manufactured by the Cutler-Hammer Manufacturing Company of Milwaukee, Wis.

All live parts of these switches are completely enclosed, and may be readily inspected by lowering a sliding panel. This operation opens the switch and the starter cannot be operated until the panel is in the closed position. All danger from live parts is thereby eliminated. The most unskilled person can operate either type, which merely requires a short radial movement of a lever projecting from the side of the enclosing case. The handles may

Starter with front cover removed showing contactors, duplex relay and low-voltage coil.

be locked to prevent unauthorized operation. Contact posts and fingers are of standard C-H drum construction, easily inspected and renewed. Their vertical position prevents the accumulation of dirt and grease. The cases are arranged for conduit wiring.

A duplex overload relay and a low voltage release coil are provided with the starter, and are both enclosed with the switch. The overload unit has an inverse time element which permits a large initial starting current or a temporary overload but protects the motor from a continuous heavy overload. The switch is made with either three or four poles.

The fused starter is especially adapted for those motors which cannot be connected directly to the line when starting. A resistor enclosed in the same casing with the switch decreases the initial voltage to 60 per cent or 75 per cent as desired, and maintains the balance of all three phases while starting. The fuses are out of the motor circuit until the rotor has reached normal speed; therefore they do not carry the heavy starting current and need be of no greater capacity than proper protection



Lowering the panel of the starter deadens the fuses and makes them accessible for renewal. The switch cannot be closed while the panel is lowered.

requires. This starter contains a low voltage release coil.

Both starters are made in various capacities for operating squirrel cage motors on potentials not exceeding 550 volts.

## Some Pointers on By-Product Coke Oven Operations

### INCREASING PRIMARY COOLER EFFICIENCY.

(Continued from page 489)

In construction, the primary cooler is usually a gas and water-tight steel shell rectangular in shape and in general arrangement about as indicated in Fig. 1. Section A A of the same figure shows the approximate spacing of the tubes through which the cooling water slowly passes and around which the gas flows, the result being the absorption of heat by the water, the reduction of the gas temperature and the condensation of the above-mentioned vapors.

It will be noted from Fig. 1 that the gas travels upward and downward the length of the tubes in passes and travels at right angles to the tubes only at the turning point where it leaves one pass to enter another, and in consequence of this the gas does not come into as intimate contact with the cooling surfaces, formed by the tubes, in sufficiently small bodies as to remove much more than 80 per cent of the tarry vapors from the gas within the cooler.

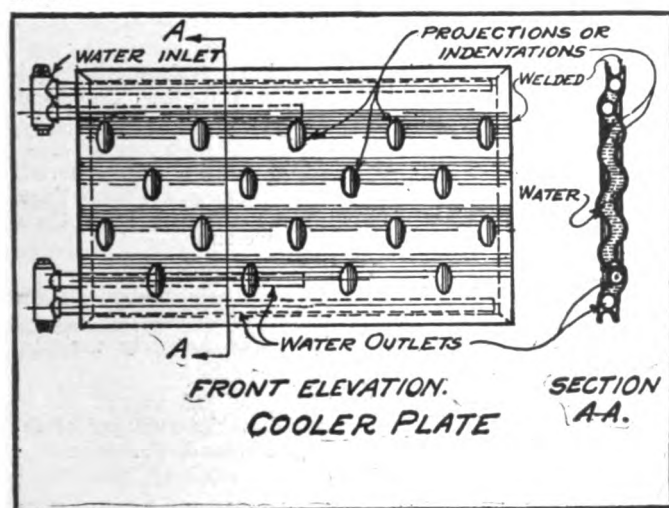


FIG. 1.

If a given volume of gas were cooled within a receptacle to the condensation point of the vapors, without its contact with any impinging surface, much of the vapors would remain suspended within the gas and would pass out with the gas. But, if the same body of gas—after being cooled—were divided into small bodies and brought into intimate contact with sufficient impinging surface practically all of the condensed vapors would be precipitated as moisture on the impinging surfaces provided, and if this principle of construction is provided within a primary cooler the percentage of tar precipitation would be so materially increased as to eliminate the use of a tar extractor for removing the final tar mist or fog which the tubular construction of cooler fails to precipitate.

A cooler plate or baffle designed on this principle and of identical construction to that of the blast furnace gas washer described in last month's issue of this periodical is shown in Fig. 3. This cooler plate differs from the gas washer baffle in that it is made up of two corrugated sheets welded at their edges to form a water tight compartment through which cooling water may flow. The surfaces of the plates are indented so that the resulting projections act as spacers and points of support for the adjacent plates, the resultant spaces being the gas passages between the cooling plates.

The cooler plates are arranged within the cooler as shown in Fig. 2 with its accompanying section. The cooler shell is of rectangular-shaped steel plate construction with cast door frames having cast flanged water inlet on top and outlet on sill of frame, the cooler plate water inlets and outlets being connected to same

as shown in section B. B. of Fig. 2.

Gas enters through the inlet near the bottom of one end of the cooler, travels upward and downward through the various passes and leaves the cooler through the outlet at the lower opposite end from the gas inlet as indicated by arrows in the sectional elevation of Fig. 2.

Water enters through the several pipe connections to the cast door frames and passes through one cooler plate and thence flows through the outlet in the cast door frame, and out into the drain pipe.

The gas in travelling through the first pass of the cooler is split up into films  $\frac{5}{8}$  inch thick. The path of the gas is wavy by reason of the corrugations of the cooler plates; the corrugations of each adjacent plate projecting within each other and the plates being held apart by the projections formed by indenting the cooler plate surfaces as above described. The spaces between the plates of first passes are greater than those of the latter passes making allowance for the heavier and more sluggish precipitations of tar which will occur in the first passes of the cooler. In the latter passes there will be precipitated the more liquid condensates and the spaces between the plates in these passes may, as a consequence, be much less.

The cooler plates of the six passes are spaced respectively  $\frac{5}{8}$ ,  $\frac{1}{2}$ ,  $\frac{7}{16}$ ,  $\frac{3}{8}$ ,  $\frac{5}{16}$  and  $\frac{1}{4}$  inch apart. The first pass contains 3,800 square feet of cooling and impinging surface and the other passes respectively 4,200, 4,400, 4,600, 4,900 and 5,300 square feet, making a total of approximately 27,000 square feet of cooling and impinging surface within the six passes.

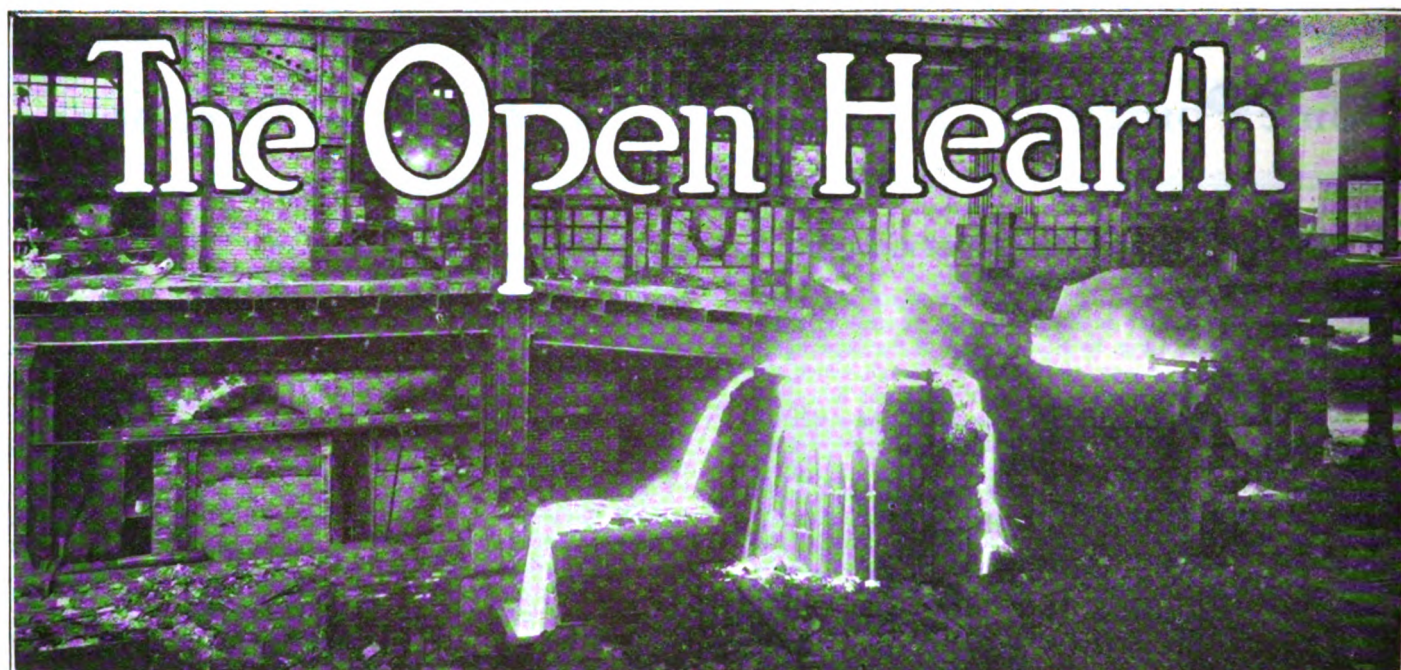
The areas are obtained within a space of 5 feet wide, 18 feet long and 20 feet high, which space, if occupied by the usual tube construction, would allow of but 18,000 square feet of cooling surface which would be far less effective than the corrugated sheet surfaces because the gas bodies travelling lengthwise of the tubes are comparatively large in section and are not brought intimately into contact with the cooling or impinging surfaces.

In the steaming out operation steam does not enter the gas passages of the cooler and mingle with the tar; which is a somewhat objectionable feature in the tubular cooler as it adds large quantities of condensed steam to be handled in the pumping, separating and distilling apparatus; but instead the main water inlet valve is closed, the line drained and the steam valve opened admitting steam to the water inlet main and thence to the cooler plates, the condensed steam passing out through the drain connections and thus heats the tar in the gas passages and causes it to flow freely from off the cooler plate surfaces.

For complete removal of tar from the gas there could be inserted in the last pass of the cooler blank corrugated plates instead of the cooler plates, the spacing of the blank plates could be as small as  $\frac{3}{16}$  inch, obtained by indenting the plates to that depth. These blank plates so arranged would provide a total of 28,000 square feet of impinging surface in the last pass, which if occupied by the water cooled plates would provide but 5,300 square feet of impinging surface.

With the latter arrangement a given volume of gas in passing through the cooler would come into intimate contact—in films of from  $\frac{5}{8}$  inch thick down to  $\frac{3}{16}$  inch thick—with 50,000 square feet of corrugated cooling and impinging surface and each cubic foot of gas would be subjected to the cooling and impinging effect of 3,300 square feet of corrugated surface, and practically all of the tar would be removed from the gas within the cooler, and without undue condensation of the benzol vapors which, as above stated, it is not desired to condense within the primary cooler. As the gas is drawn through the cooler by a fan or exhauster, the gas will not tend to short circuit through the ends of the cooler plates, but by reason of the suction maintained by the exhauster, the gas seeks the shortest path through the cooler, which is that between the corrugated surfaces of the cooler plates.





John N. Allen is now manager of the steel, coal and coke department of the National Trading Company, Cleveland, O., after having resigned as general manager of the mining and transportation department of the Brier Hill Steel Company, Youngstown, O.

V V

W. Aubrey Thomas has been elected president of the Jenifer Iron Company, Jenifer, Ala. John M. Thomas, Milwaukee, Wis., is vice president and the secretary-treasurer is T. E. Thomas.

V V

A. M. Moreland, has been elected treasurer of the Slick-Knox Steel Company, Wheatland, Pa. He was formerly with the Carnegie Steel Company.

V V

W. J. McClain, who has been associated in the management of the Buffalo office of the Republic Iron & Steel Co. for the past six years now has charge of the sales department for the Buffalo district.

V V

J. R. Stroh, has been made manager of the mining department of the Brier Hill Company to succeed John N. Allen, resigned.

V V

A. A. Schneider has been appointed manager of the newly created raw materials division of the American Steel Export Company, New York.

V V

E. F. Kidd has been made traffic manager of the Republic Iron & Steel Co., Youngstown, O., to succeed Henry K. Moore, deceased.

V V

Thomas Silk has resigned as superintendent of the steel barrel and range boiler department of the Whitaker-Glessner Company, Portsmouth, O., and has accepted a similar position with the Boyle Manufacturing Company, Los Angeles, Cal.

V V

John I. Reid, formerly works manager of the Chester, Pa., plant of the American Steel Foundries, and later, superintendent of the Longue Point works of the Canadian Steel Foundries at Montreal and Quebec, has been appointed general superintendent of the Canadian Steel Foundries.

William Thompson has been appointed assistant to President Palmer of the American Steel & Wire Co., Cleveland, succeeding Alvah S. Chisholm, deceased.

V V

A. A. Schneider is now manager of the raw materials division of the American Steel Export Company, New York. He was formerly connected with the Cambria Steel Company.

V V

S. H. Hedges has been made purchasing agent of the Republic Iron & Steel Co., Youngstown, succeeding Charles I. Starrett, resigned. Mr. Hedges was formerly assistant purchasing agent.

V V

H. P. Barnard has been appointed works manager of the Pittsburgh Crucible Steel Company, Midland, Pa.

V V

E. R. Doud, has now opened offices in the Miners Bank Building, Wilkes-Barre, Pa., as direct manufacturer's representative, handling a complete line of iron, steel and metal products. Mr. Doud resigned his position as general superintendent of the Tioga Steel & Iron Co.

V V

O. Robert W. McDonald, has resumed his former position as superintendent of the Crescent works of the Crucible Steel Company. He had been acting as works manager of the plant.

V V

At a recent quarterly meeting of the board of directors, W. D. Truesdale was elected treasurer of the Inland Steel Company, Chicago.

V V

George Foraker has been made general superintendent of the Pacific Coast Steel Company, San Francisco, Cal., succeeding C. E. Duncan, resigned. He was formerly assistant general superintendent.

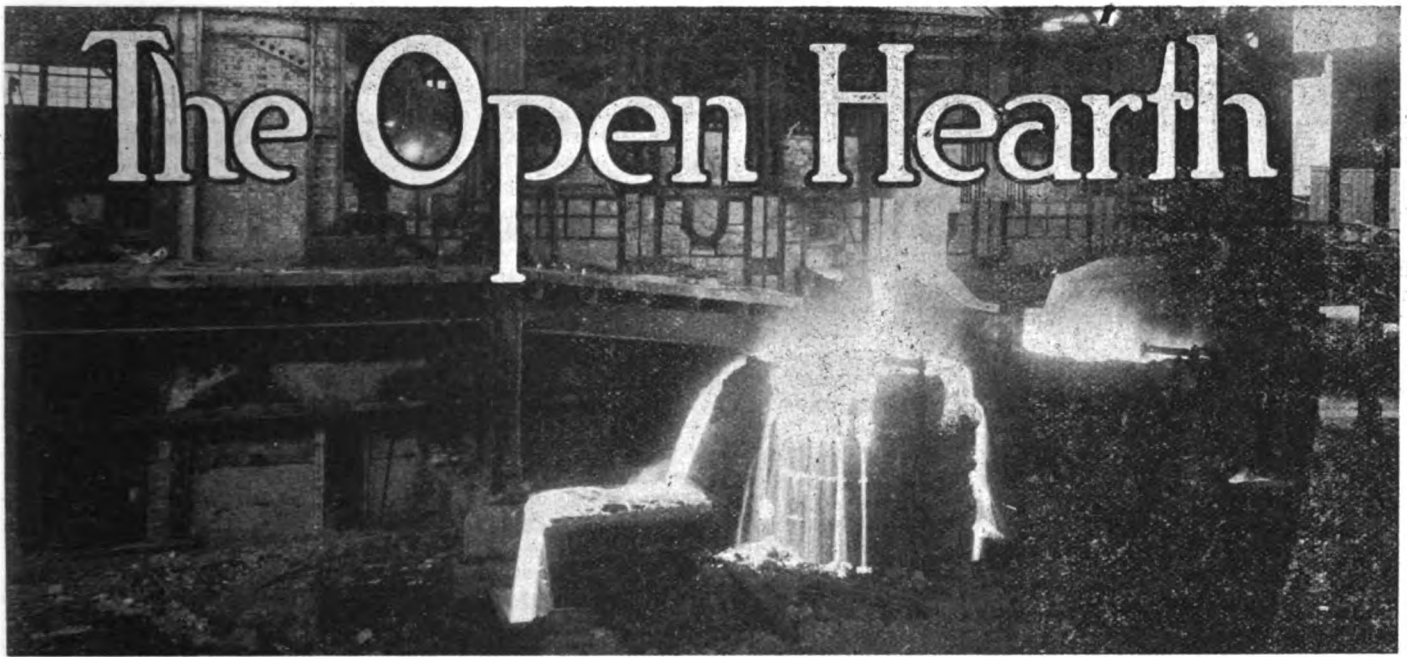
V V

J. O. Griggs has been made senior melting foreman with the Brier Hill Steel Company, Youngstown, O., after having resigned as foreman in the open hearth department of the Sharon Steel Hoop Company, Sharon, Pa.

V V

Walter A. Janssen has been appointed assistant general manager in charge of operations of the American Steel Foundries, New York, Chicago and Pittsburgh with headquarters at Chicago. He was formerly operating manager





of the plants for the Canadian Steel Foundries, Ltd., with headquarters at Montreal.

✓ ✓

Hamilton Stewart, Pittsburgh, was recently elected director of the Crucible Steel Company of America.

✓ ✓

Stanley H. McKee has been appointed chief engineer of the Republic Iron & Steel Co., succeeding J. C. Shackelford, resigned.

✓ ✓

Gen. T. Coleman du Pont and Henry Payne Whitney, have been elected to positions on the board of directors of the Vanadium Steel Company of America.

✓ ✓

C. A. Thayer has accepted the position of chief engineer of the One Hundred and Eighteenth street steel plant of the Interstate Iron & Steel Co., Chicago, after resigning his position with the Canadian Steel Corporation, Ltd., Ojibway, Ont.

✓ ✓

D. B. Fulton has become assistant in the sales department of the Railway Steel Spring Company, Chicago. He was formerly assistant to the chief engineer of the American Brake Shoe & Foundry Co., New York.

✓ ✓

E. McCormack, who was formerly treasurer of the Railway Steel Springs Company, New York City, has been made assistant to the president. He is succeeded by H. S. Bankhart.

✓ ✓

William Parry will become assistant superintendent of the Union Alloy Steel Company, Canton, O., after having resigned as an assistant superintendent of the Sharon Steel Hoop Company plants in the Youngstown district.

✓ ✓

N. S. Braden, former sales manager, has just recently been elected vice president of the Canadian Westinghouse Company, Ltd., of Hamilton, Ont. H. M. Bostwick, assistant sales manager, has been appointed sales manager, to fill the vacancy created by Mr. Braden's promotion.

✓ ✓

F. D. Egan, former works manager of the Pittsburgh Iron & Steel Foundries Co., has accepted a position in the general engineering department of the Westinghouse Electric & Manufacturing Co., at East Pittsburgh, Pa., where he will devote his entire time to the development of electrical apparatus for steel mill application. Mr. Egan's experience

with electrical apparatus as applied to steel mills has extended over a period of a score of years, all of which time was spent in mills in the Pittsburgh district. In 1899 he entered the electrical department of the Carnegie Steel Company's Homestead plant, working under the direction of Alva C. Dinkey, then superintendent of the electrical department. He resigned this position in 1903 to enter Grove City College, where he completed his college course. After graduating from school, he went to work in the inspection department of the Westinghouse Electric & Manufacturing Co., remaining a little over one year, leaving there to accept a position with the Carnegie Steel Company, Carrie Furnaces, where he served as assistant chief electrician during the construction of their numbers 6 and 7 blast furnaces. When this work was completed he joined the electrical engineering force of the National Tube Company.

While working for the tube company Mr. Egan devised a plan whereby he could attend the engineering school of the University of Pittsburgh and at the same time devote a major portion of his time to his work. After successfully laying his plans before the management, the aspiring engineer entered the university, where he studied for two years, when he found it necessary to give up his course for the time being in order that he might enter the electrical superintendent's office. As a result of considerable study and hard work, he was later promoted to assistant superintendency of the electrical department.

#### STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC., OF

### The Blast Furnace and Steel Plant

[Required by the Act of Congress of August 24, 1912]

Name of Publication: **The Blast Furnace and Steel Plant**, published monthly at Pittsburgh, Pa. [Report for October 1, 1918.]

Publisher—National Iron and Steel Publishing Company, 108 Smithfield street, Pittsburgh, Pa.

Engineering Editor—Alfred M. Staehle, 108 Smithfield street, Pittsburgh, Pa.

Managing Editor—Herbert A. Andresen, 108 Smithfield street, Pittsburgh, Pa.

Business Manager—Fred C. Andresen, 108 Smithfield street, Pittsburgh, Pa.

(Names and addresses of stockholders holding 1 per cent or more of total amount of stock):

Herbert A. Andresen, 108 Smithfield street, Pittsburgh, Pa.

Fred C. Andresen, 108 Smithfield street, Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

FRED C. ANDRESEN, Business Manager.

Sworn to and subscribed before me this 25th day of September, 1918.

JOHN N. ENGLISH, Notary Public.

(My commission expires March 9, 1923.)

### Trade Publications

The Quigley Furnace Specialties Company, has issued a new booklet describing Carbosand, a refractory granular material for making rammed in linings, special tile, patches and repairs in furnace structures.

The Celite Products Company, 11 Broadway, New York City, is issuing a new and interesting bulletin describing in detail, standard engineering practices of insulating various types of furnaces; such as annealing, heating, forging, malleable, gun, glass, etc. Copies of this bulletin B-8-A will be mailed on request to anyone interested in this subject.

C-H Drum Controllers is the title of a new four-page two-color 8½x11 folder, which has been prepared by the Cutler-Hammer Manufacturing Company, Milwaukee. It gives prominence to the outstanding features of C-H Drum Controllers which have won for them an enviable position in the drum controller field. Three of the features are: Accessibility, interchangeability, of parts and interchangeability of methods of manipulation. Any C-H standard stock drum can be equipped with either rope, radial or straight line drive and these are interchangeable. The folder plays up other points, such as, the ease with which the contact fingers and the cylinders may be removed; the absence of wood in construction; the square metal shafts, and the straight non-stubbing fingers. Dimensions, ratings and other engineering data are given. Three types having common dimensions comprise five bulletin numbers, capable of controlling ac and dc motors from 1 to 100 hp. The folder was prepared especially for the St. Louis convention of the Association of Iron and Steel Electrical Engineers but is also being forwarded to those interested in drum controllers.

### Trade Notes

The Lewis Steel Products Company, of Toledo, is planning early construction on a new building on a site just purchased here. The structure is to cost \$100,000. The expansion is made with the view of making the concern the largest manufacturers of iron head valves in the United States. The new building will be two or three stories high, the plan being to erect the foundation for additions when they are necessary. The Lewis Steel Products Company is headed by A. R. Class, as president. The company was formerly owned by George L. Lewis, having been sold to Class and his associates early in the year.

The following market report is issued September 20 by the Matthew Addy Company:

"The iron trade keeps on making progress in the face of difficulties. There are two great difficulties, and one

might just as well tell the plain truth. First is labor. It takes just about twice as many men to accomplish a given result as it did five years ago. Except for the fact that conditions in the world are upset, it is easy to see that this state of affairs would soon, were there strictly competitive conditions, put America out of the running. It is a kind of a picnic that labor and business are enjoying; certainly it is not either real labor or real business. Secondly, the railroads are inefficient. Their service is poor, there is no snap and get-up to them. The vast losses which we are suffering because the railroads have not enough empty cars to take care of all the freight that is offered can hardly be computed. And wherever you go the problems that are uppermost are the troubles and hinderances and delays which are met at every turn. Prices are more than 100 per cent higher than before the war, yet even these excessive prices, such is the enormous cost of production, leave no adequate margin. It is not a very pleasant picture, yet it is a true one.

Apart from this most disagreeable feature the week has repeated recent history. There has been fair buying of odd lots. Inquiry for 1920 is heavy, but sales ahead are few as no one yet is sure of 1920 costs. It is too much of a gamble to sell iron and steel over the first half of next year when the manufacturer can only guess what it will cost him to produce.

After an extensive investigation of the various types of electric furnaces and a visit to the United States Navy Yard at Puget Sound, where a 6-ton Greaves-Etchells furnace is in operation, the Vancouver Engineering Works, Ltd., Vancouver, B. C., has given an order to the Electric Furnace Construction Company for a Greaves-Etchells furnace.

The continued activity and development of Italy as a field for American machinery and equipment and steel and metal products has been one of the interesting phases in export work in the last six months and has been watched with interest by exporters throughout the country.

So large has seemed the opportunity to M. Ferraris & Co., agents of the American Steel Export Company for Italy, that Joel B. Ives of the engineering and contracting department of the export company has just sailed on board the S. S. Guiseppe Verdi. He will confer with the Italian agent as to means and methods for adequately dealing with the situation and insuring a continuance of the effective sales service already rendered in that territory.

During the past week there was organized in Chicago a new corporation under the laws of the State of Illinois to be known as the Booth Electric Furnace Company, with paid up capital of \$1,000,000. Of this amount one-half is preferred stock, and one-half common. The new company has acquired all the patents, assets, and good-will of the Booth-

Hall Company, well known as manufacturers of electric steel and brass melting furnaces, and has taken over the business formerly carried on by that company. It will greatly enlarge the scope of operations, and develop the electric furnace business along standard manufacturing lines rather than on a special engineering contracting basis.

The Booth rotating furnace which has been in successful operation during the last six months, and which is especially designed for the melting of non-ferrous metals, has been thoroughly developed and standardized, and the company is prepared to deliver this type of furnace in four sizes, viz., 250-lb., 500-lb., 1,000-lb., and 2,000-lb. equipments.

The well known two-phase, two-electrode Booth-Hall furnace for the melting of iron and steel will also be made in five sizes, i.e., ¼-ton, 1½ ton, 3-ton, 6-ton and 12-ton. An improved type of furnace, oval in shape, has been designed, and prompt shipment can be made of anyone of these five sizes.

Associated in the management of the company will be a number of the best known engineering and operating executives in the public service field. L. E. Myers, of Chicago, president of the L. E. Myers Company, has been elected president of the new corporation; C. H. Booth, formerly president of the Booth-Hall Company, vice president; W. K. Booth, formerly chief engineer of Booth-Hall Company, secretary, and L. J. Clark, of the L. E. Myers Company, treasurer. In addition to the president, vice president and secretary, the board of directors will include Martin J. Insull, vice president of the Middle West Utilities Company, and E. W. Lloyd, of the Commonwealth Edison Company, both of Chicago.

The new company is prepared to carry on an aggressive campaign for business, and will open sales offices in different parts of the country to properly handle its business. An adequate engineering staff will be maintained to cooperate with customers in connection with their electro-metallurgical problems, especially those relating to the melting of metals.

### Society Meetings

The coming semi-annual convention of the American Gear Manufacturers Association which will meet at Boston, October 13-16, promises to have the largest attendance and be the most interesting meeting yet held by this association. A friendly rivalry has been stirred up among the member companies, by dividing them into groups, each of which is endeavoring to have the largest representation present at the convention.

An interesting program has been prepared and one of the important subjects to be discussed will be gear standardization, which has been given close study by committees appointed for that purpose.



# The Blast Furnace *and* Steel Plant

Pittsburgh, October, 1919.

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